MANAGING INTERNATIONAL TECHNOLOGY TRANSFER

A STRATEGIC APPROACH
FOR DEVELOPING COUNTRIES

KURT HOFFMAN AND NORMAN GIRVAN

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A Strategic Approach for Developing Countries

Kurt Hoffman and Norman Girvan

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PREFACE

The IDRC Science and Technology Policy Workshop Programme was launched in 1976. The objective and target audience of the Programme, as well as its organization and methods of training were unique in many respects. The Workshops were intended to both increase participants' awareness of the importance of science and technology issues and, most significantly, to strenghten their capacities for research and analysis in support of policy formulation. It was this latter concern with the development of policy research capabilities that especially set the IDRC Workshop apart from similar programmes conducted by other agencies.

At the time the Programme was initiated, a sizeable share of Third World policy making expertise and research capability in the field of science and technology policy was concentrated within Latin America. This was reflected in the fact that most of the Centre's early support for research projects in the field was provided to institutions and researchers from this region. In a limited way, the Workshops Programme attempted to redress this imbalance by adopting a regional focus and seeking explicitly participants from Africa, Asia, the Middle East and the Caribbean. Thus, nearly 200 policy makers and researchers from these regions attended eight IDRC Workshops held in two phases between 1977 and 1983.

Emphasis was also placed on getting the best mix of participants from different types of backgrounds, i.e. policy makers and researchers; social scientists and engineers/scientists; and representatives from different institutions such as ministries, universities, national science councils and regional bodies.

With one exception,* all of the Workshops were concerned with the problem of developing and implementing policies that would exploit science and technology to further industrial development in the Third World. Within this broad area, the Workshops'primary focus was to examine and understand how developing countries could best accumulate indigenous scientific and technological capacities through national policies and, in particular, through the effective management of the process of international technology transfer.

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*One of the workshops held at the Science Policy Research Unit in 1978 was concerned with technology policy for the rural energy sector.

While this approach, by the late 1980s, became a mainstream concern of the field, it in fact represented a major departure from the conventional wisdom of the 1970s. The common perception then was that technology transfer was primarily a mechanism by which international corporations could extract monopoly profits from developing countries and at the same time increase these countries' technological and economic dependency on the North. The Workshops adopted an entirely different perspective - one that emphasised the great possibilities for using the transfer process as a technological and institutional learning mechanism, and the need for careful research that could provide the foundation for policies to exploit this potential.

The Programme's emphasis on fostering participants' research, analytical and policy formulation skills led to the development of a number of innovative approaches to training that were employed during the Workshops. Three deserve particular mention here. The first involved the use of the "literature". Limited access to the literature, particularly unpublished empirical studies, and to information about the experiences of other countries, severely constrains the effectiveness of the work of Third World policy makers and researchers by denying them the opportunity to learn from the experience of others.

Consequently, each Workshop participant was provided with a comprehensive set of articles, books, chapter extracts and monographs that in effect constituted a mini-library in the field of science, technology and development. The material provided was organized into topic 'modules' for each session which participants had to study and review intensively in order to participate fully in the Workshop. More importantly, it was hoped that by making this material available to the participants' institutions when they returned home, it would serve as an important resource in their work and that of their colleagues. Full bibliographic information regarding this literature is provided in the third section of this volume.

Secondly, an instructional format had to be devised that would maximise the 'training' and 'learning' aspects of the Workshops. To reduce the time constraints inherent in short courses, the Workshops were relatively long - ten weeks in Phase 1 and four weeks in Phase 2. Workshop sessions were organized around structured sets of 'core' lectures presented by a small number of full-time staff who were present during the entire period.

These core lectures, focusing on different aspects of the central themes of the Workshop, drew heavily on the material supplied to the participants. Much use was made of empirical evidence and case study material to illustrate both concepts and research method. The lectures invited participation from the floor during presentations, and these were followed by open discussion periods where extensive involvement by the participants was expected and encouraged. This combination of duration and format allowed participants and staff to pursue an in-depth exploration of policy issues and research questions.

Thirdly, opportunities were provided for participants to pursue individual interests and projects during the Workshop. This took a variety of forms - presentations to the group, one-to-one sessions with Workshop staff, guided reading on particular topics, and specially organised visits to outside institutions. As with the formal sessions, the objective of these individual activities was to give participants the chance to be fully engaged in a learning process that was directly relevant to their professional interests.

Finally, in Phase 2 of the Workshop Programme, which took place in Africa and the Caribbean, participants carried out their own research projects. Organised into multidisciplinary teams, they established their own research objectives and methodology. Arrangements were made for them to visit local enterprises to collect information and data. This material was discussed and written up by the teams, and then presented to the Workshop in formal session.

These mini-research exercises were a vital part of the Workshop learning experience since they brought to life many of the concepts and issues being discussed during the sessions. Moreover, they allowed participants, some of whom had never even been inside factories before, to gain first-hand knowledge of the empirical research process. Many of the written reports constitute a valuable contribution to our knowledge of conditions in the industrial sector in countries on which empirically-based information is usually very limited.

Many individuals and institutions have contributed to the success of the Workshop Programme. Initial support for its establishment was given by Dr Geoffrey Oldham in his capacity as Associate Director of the IDRC Science and Technology Programme and this was continued by his successor Tony Tillett. The first phase of the Workshop Programme was based at the Science Policy Research Unit of the University of Sussex in Brighton, England, where four workshops of ten weeks' duration were held between April 1977 and June 1979. This phase was directed by Martin Bell who, with the support of Kurt Hoffman, developed the focus, core concepts and bibliographic materials on the management of technology transfer and capability accumulation on which the entire series of Workshops was based.

For the second phase, a number of changes were introduced. Norman Girvan acted as Workshop Director for this phase, with Kurt Hoffman again providing support as co-designer of the curriculum and chief co-instructor. A major addition was also made to the topics covered with development and inclusion of an extensive component of lectures dealing with national technology planning and policies.

Also it was decided to shorten the duration of the Workshops and, most importantly, to hold them in developing country locations.

Consequently, in Phase 2, four one-month Workshops were held at three locations in Africa (Tanzania in April 1982, Liberia in October 1982 and Senegal in April 1983) and one in the Caribbean (Jamaica in November 1983). These Workshops were all carried out in collaboration with local academic institutions: the Institute of Development Studies (IDS) of the University of Dar-es-Salaam, the University of Liberia, the African Regional Centre for Technology (CRAT) in Dakar, and the Institute of Social and Economic Research (ISER) of the University of the West Indies.

This feature of the Workshops enabled participants to get direct empirical exposure to technology issues in a developing country environment, as well as to have access to the work of local scholars and to have the benefit of viewing issues from the perspectives of local decision-makers, of whom the Workshop made ample use. It was in order to take advantage of the opportunities this afforded, that Phase 2 featured the incorporation of multidisciplinary team research by participants as an integral part of the teaching programme.

Throughout the course of the Programme, a number of individuals acted as resource persons and made substantial teaching inputs at multiple workshops - Dr Kadir Djeflat, Dr Raphie Kaplinsky, Don-Scott Kemmis, Dr Steven Langdon, Dr Lynn Mytelka, Maurice Odle, and Peter O'Brien. Many other professional policy makers, researchers and industrialists from both developed and developing countries, who are too numerous to mention by name, also gave help and support in a variety of ways. Finally, many professionalas at IDRC were instrumental in the success of the Programme, both in terms of providing key administrative and liaison services and more importantly by acting as a constant source of enthusiastic encouragement and wise advice. Tony Tillet, Christopher Smart and Jamieson Campbell deserve particular mention here in this regard.

The contributions of the Workshop Programme have emerged in a variety of ways. In addition to the benefits gained by individuals from their attendance, the programme helped create a new set of personal and professional linkages between participants, staff and the Centre that continue in the present. A considerable number of researchers either pursued the D Phil degree or have subsequently participated in research projects in the field. Many of these projects have been supported by the IDRC and have resulted in publications that have made a substantive contribution to the field.

Many of the policy makers who attended the Workshops continue to work professionally in the field and use the expertise and information gained in their daily activities; some of these have even initiated a variety of projects and programmes within their own institutions and agencies that drew directly on their Workshop experience.

The success of the Workshop Programme also stimulated a number of international agencies to sponsor similar exercises. For example, a major programme of science and technology policy seminars was conducted by the World Bank. In addition, the UN Economic Commission for West Asia (ECWA) held a four-week Technology Policy Workshop for the Arab Region in Baghdad, Iraq, in June 1985; during 1984 and 1985, the African Regional Centre for Science and Technology in Dakar, Senegal, sponsored a number of regional science and technology policy workshops throughout Africa; and most recently, the Institute for Social and Economic Research of the University of the West Indies in Jamaica held a four-week Workshop in Kingston in September 1986. All of these efforts drew inspiration from, and in some cases were modelled on, the IDRC Workshops.

Given the strong interest in the issues addressed and in the material presented in the Workshop Programme, the Science and Technology Policy Program of the IDRC has decided to publish a selection of the teaching and research material produced for the Workshops. This first volume consists of three sections. The first section contains the set of 'core' lectures given during the workshops by Kurt Hoffman. These analyse the process of international technology transfer with the objective of showing how strategies may be developed at the enterprise level to bring about the effective acquisition and assimilation of imported technology.

The second section is a set of complementary lectures on national technology policies and planning by Norman Girvan. These set out in schematic form the approach which might be taken by policy makers in a developing country with a weak science and technology infrastructure and little experience and tradition in technology policy making. They suggest how a government may develop strategies and policy instruments aimed at encouraging the management and acquisition of imported technology by enterprises, complemented by the selective development of local technological resources and capabilities by direct governmental action.

Both sets of lectures were refined continuously during the course of several Workshops as a result of feedback from participants. The final section provides the extensive bibliography developed during the course of the two phases of the workshops, divided into principal subject areas.

There is ample demonstration in the literature of the enormous contribution that technology can make, and has made, to the economic development and social well-being of nations. Finding ways to harness this potential is a crucial task facing developing countries. In publishing this material, the IDRC hopes to continue to stimulate interest in the subject area amongst researchers and policy makers from different disciplines, to make available more widely the teaching material and core bibliography developed for the workshop, and so to contribute towards the achievement of better understanding and more effective policies for technology transfer and development.

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SECTION ONE

TECHNICAL CHANGE, TECHNOLOGY TRANSFER AND INDUSTRIAL DEVELOPMENT IN THE THIRD WORLD

Nine Lectures by Kurt Hoffman

ACKNOWLEDGMENTS

I was fortunate to be able to spend my "apprenticeship" in the field of technology and development working closely with Martin Bell, a friend and former colleague at the Science Policy Research Unit of the University of Sussex. Martin's meticulous scholarship as a researcher set a standard to which I could only aspire, while his deep insight into the relationship between science and technology and the development process were and are a constant source of knowledge and inspiration in my own work. Indeed, many of the ideas and concepts in these lectures have their origin in his writings and in the hours of discussion that we shared over the years.

I know that I speak for many colleagues, researchers and policy makers when I gratefully acknowledge the tremendous intellectual contribution that Martin Bell has made to our field. We have all benefited greatly from the clarity of his vision and from his dedication to the cause of Third World development.

TECHNICAL CHANGE, TECHNOLOGY, TRANSFER AND INDUSTRIAL DEVELOPMENT IN THE THIRD WORLD

Kurt Hoffman

INTRODUCTION

There is a common lesson that can be drawn from the industrial history of countries as diverse as the United States and Germany in the late 19th century, Japan in the mid-20th century and South Korea since 1960. A key factor in their successful industrial development is that they first accumulated a pool of skilled human resources - such as craftsmen, engineers, scientists, technicians and managers - and were then able to use these indigenous 'capacities' to devise technical solutions to their own problems both by adapting and improving imported equipment and know-how to suit local conditions and by developing entirely new and more appropriate ways of solving their problems.

Thus, all of these countries possessed an internal technological "dynamism" that yielded a steady stream of technical improvements to their methods of industrial production. And it is this flow of innovations that constituted a crucial source of the continual rise in productivity that provided the steady rise in living standards enjoyed by these societies. Unfortunately, most developing countries, even in the late 1980s, still lack this internal technological dynamism. Consequently, despite their efforts to industrialise over the last thirty years, they have been unable to harness the driving force of one of the most powerful motors of economic development.

It was a central tenet of the IDRC Workshops that this situation, though costly and difficult to change, was not intractable and need not be an inevitable characteristic of the future of the Third World. The core lectures of the Workshops therefore concentrated on exploring two themes. The first was that it is possible for Third World governments and firms to consciously devise policies that can both foster the process of accumulation of indigenous technological capacities and create conditions that allow effective deployment of these domestic capabilities to solve local problems. The set of lectures in this volume, prepared and originally presented by Dr Norman Girvan, specifically addresses these issues.

The second theme of the Workshop was concerned not with the formulation of policies but more with understanding the processes by which indigenous technological capacities could be created and accumulated. Though there are arguably many routes by which this can be done, the Workshop was primarily interested in one particular mechanism, that of international technology transfer from developed to developing countries. The key line of argument explored under this topic was that the process of technology transfer, effectively managed, could provide unique opportunities for recipient firms to acquire technological know-how and skills not available to them by any other means.

Understanding and analysing the process of technology transfer from this perspective is the focus of this set of Workshop lectures. This is done in stages through a set of nine lectures. Lectures One and Two present the concepts, evidence and arguments that place technical change and the human and institutional capacities for effecting this as one of the primary forces underlying the process of industrial development in both developed and developing countries.

Lecture Three critically reviews the conventional wisdom of the 1970s that judged the potential contribution that technology transfer could make to Third World development from an essentially negative perspective. Lecture Four presents an alternative approach to the analysis of technology transfer that emphasises the need to understand its potential as a "learning" mechanism so that policies can be designed that will exploit these possibilities.

Lectures Five, Six and Seven adopt this approach in examining what is called the 'pre-investment' phase of technology transfer. Empirical evidence is used to examine the costs and benefits of developing countries' efforts to identify and negotiate with foreign sources of industrial technology. Emphasis is given to the fact that effective management of the pre-investment phase is the key to the successful acquisition of technological capacities through technology transfer. Lectures Eight and Nine continue this mode of analysis by focusing on the problems, the prospects and the policy tools available for maximising learning during the 'investment' phase of technology transfer.

Due to the efforts of a great many researchers, there is now a valuable and growing body of empirical and analytical studies concerned with the relationship between technical change, technology transfer and industrial development in the Third World. One of the primary aims of these lectures was to simply and briefly present a synthesis of only some of the main ideas to be found in this body of knowledge. Thus, the concepts, arguments and evidence presented in the lectures draw heavily on the existing literature, and I am indebted to all of those authors for their insights and scholarship - both those to whom I have referred directly in the text and those whose contributions to my own learning may have gone unnoted here but are nevertheless deeply valued. Of course, all mistakes in interpretation are my own responsibility.

One final set of comments. These lectures were prepared for verbal presentation. Consequently, they differ considerably from written material intended for publication, in structure, use of evidence, and in the logic of the argument presented. The reader should also note that they were designed to be given within the particular context of

Workshops that placed heavy emphasis on learning from the available literature. As a result, it was assumed that the Workshop participants had done fairly extensive preparation by reviewing assigned material prior to the lecture sessions. In preparation for this volume, revisions have been made to the lectures so that they can be understood without extensive prior knowledge of the literature referred to in the text. However, the lectures should not in any way be considered as a substitute for the original empirical and analytical studies on which they draw heavily. Much more will be gained from the lectures if the reader is able to review some of this material as well.

LECTURE ONE

INNOVATION, TECHNICAL CHANGE AND DEVELOPMENT: EVIDENCE AND IGNORANCE

So much has been written and said about the crucial role that science and technology have played and continue to play in the process of economic development that it may seem unnecessary to belabour the point. Some may view technology as a means of human enslavement, as a Pandora's box that will lead eventually to the destruction of society - and as such see it is a force that needs to be constrained. Alternatively, others may see technology as a source of human liberation, as providing a means of escaping drudgery as well as mindless, dangerous and degrading work - and they therefore believe that the further development of technology should not only be continuously promoted, but that it should also be diffused as quickly and as widely as possible.

Whether we curse or we bless technology, I am quite sure that the one thing we are not guilty of is ignoring the impact that technology and technological advance continually has on our lives, on the lives of our friends and family and on the society in which we live.

Unfortunately, I am equally sure that many Third World policy makers concerned with planning for industrial development, and with the implementation of industrial projects are either unaware of the importance of technology and the role of technical change as a driving force for economic development; or else if they are aware, are unable or unwilling to take the necessary steps to bring the process of technical change and the use of technology under the control of local firms, institutions and people.

This suggests that one of the principle aims of technology policy research must be to generate the evidence necessary to illustrate the importance of technological progress so that the perceptions of policy makers can be changed. I understand the concept of technological progress as that process whereby societies, and firms and individuals within these societies, use technical knowledge to improve the means of production, and thereby make better use of available resources to produce goods and services. Put in this way, the concept is admittedly an abstract one. Fortunately, however, the concrete effects of technological advance on the economic fortunes of countries both historically and in more recent times are extensively well documented. In this first lecture, I would like to review some of that empirical evidence by drawing on the experience of both the industrialised countries and those in the Third World. My objective is primarily a polemic one and that is to establish the importance of the phenomena on which I place so much emphasis throughout this set of lectures.

1. The Evidence from Industrialised Economies

There are numerous examples of the process of technological advance at work in all sorts of economy under many different types of conditions. As might be expected, the most abundant body of evidence comes from the historical experience of the currently industrialised countries. The available evidence can be grouped at four levels - at the level of the firm, at the level of the sector, at the national level and at the international level.

The role of technical change at the level of the firm

Professor Chris Freeman's book, The Economics of Industrial Innovation, (1974) presents a wealth of material on firm-level technical change, particularly in the chapters describing the evolution of the chemical and synthetic materials industry in Germany, Switzerland and the US. He shows, for example, that as far back as the mid-19th century, chemical firms such as BASF in Germany and CIBA in Switzerland were carrying out in-house R&D in order to generate new knowledge and new products with the explicit aim of capturing market share. Freeman also has an extensive discussion on the impact of the R&D efforts undertaken by the German chemical firm, I.G. Farben, during the period between 1925 and 1939. He shows how these efforts were instrumental first, in establishing Farben as the dominant firm in the world in synthetic materials; second, how the technical advances generated by its R&D efforts greatly facilitated the further development and widespread use of synthetic materials throughout the economies of Europe and North America; and third, how the success of Farben in turn laid the groundwork on which the chemical sector played such an important role in Germany's rise to joint industrial hegemony in the world economy with the United States in the post-war period.

A few of the facts presented by Freeman bear this out. Between 1925 and 1939, the R&D programme of I.G. Farben was the largest in the world and as a result of this intensive investment in innovative effort, the firm accounted for 17 percent of all patents taken out in this sector in the world. No other firm except Dupont had as many as one-sixth of the patents taken out by Farben in that period. (And during the period, it is interesting to note that more patents were taken out in plastics during the 14 years from 1931 - 1945 than in the previous 140 years).

Freeman also compares the Farben performance in the area of patenting with the two early post-war leaders, Dupont of the United States and ICI of the United Kingdom. The dominance of the German company is clear from Freeman's analysis - indeed, even after World War II, after the Allies had broken Farben up into smaller companies (and in the process of doing this had made many of its secrets available to French, American and British firms), the innovative output of the smaller Farben-related companies, and their share of the market, was greater than that of any other firm in the immediate post-war period with the exception of Dupont.

The Farben example is one of many such cases related in the Freeman book and in the work of people like Nathan Rosenberg, Samuel Hollander, Bela Gold and others, which demonstrate conclusively the direct connection between innovative effort at firm level and commercial success. (See Rosenberg, 1976; Hollander, 1965; Gold, 1975).

Innovation at the sectoral level

Moving on to the sectoral level, one of the papers in Nathan Rosenberg's book, Perspectives on Technology (1976), cites the research done by John Enos from Oxford University on the economic implications of the process of technical change in the US oil industry. Enos compared changes in the level and type of production inputs (in terms of raw materials, capital,labour and energy) used per 100 gallons of petrol produced by US oil refineries in the years 1914, in the 1940s and in the 1950s. His results show that as a result of technical improvements in refinery technolgy the unit capacity of oil refineries increased from 90 barrels a day to more than 36,000 barrels a day over that period. Other improvements were effected as well - there was a 98 percent saving in labour costs, an 80 percent saving in the use of capital, and over 50 percent saving in the use of material inputs - all of these of course being measured per unit of final output. While startling, this is not an uncommon example of the historical impact of technical change at the sectoral level. Another example of sectoral advance cited by Rosenberg, is the performance of the US blast furnace industry between 1900 and 1960, during which time overall labour productivity increased by 300 percent and output per man-hour increased by 530 percent. At the same time, enormous scale economies were gained - in 1900, the total US pig iron production of 15.4 million tons was achieved by 406 blast furnaces with an average annual output of 38,000 tons while by 1960, total output was over 67 million, produced by only 263 furnaces, with annual output per furnace having risen to 256,000 tons.

Impact of technical change at the national level

It is precisely the sort of technical progress documented above - which begins, of course, with the efforts of individual firms, extends to the sectoral level, and then is multiplied across many firms and many sectors at the national level - which has clearly been of such fundamental importance to economic development in the developed countries. This last statement is borne out if we consider national level indicators of the historical relationship between technical change and the economic performance of the OECD countries. Here we can cite the well-known work by American economists, Solow, Dennison and Kendricks, who, in separate studies, have shown that over the period 1890 to 1960 technological advance (as measured by the so-called 'residual factor'), has been responsible for 50-70 percent of increases in output over the 70-year period. Similarly Peck and Otto's work on Japan showed that between 1953 and 1971, technical change was responsible for more than 20 percent of the total increase in Japan's national income.

Similar relationships have been documented for the other OECD countries and all point to economic growth being spurred on by continual rises in total factor productivity - based not on additions to capital stock (as predicted by some segments of growth theory) but by improvements to the existing capital stock. This point has extremely important implications for the process of technology transfer in developing countries to which we shall return below and in subsequent lectures.

A second type of empirical analysis related to the interaction between technical change and trade performance in the OECD countries has established that a country's ability to generate a stream of successful innovations greatly influences its competitive position in international markets for manufactured exports.

This work carried out in part by the Science Policy Research Unit examined the relationship between the level/degree of a country's innovative activities and its share of world trade. The hypothesis tested in this work was that if a country demonstrated a high degree of innovative effort, it would enjoy a high share of world trade in manufactured exports because of the competitive advantages which accrue to the innovating country. The variables measured were investments in R&D and patenting behaviour (where patents were used as a proxy for innovative output), correlated with international trade share. This relationship was shown to be very strongly positive for the main OECD countries across 40 industrial sectors. This evidence underlines the importance of the innovation process in determining the ability of an economy to prosper and withstand the pressure of international economic forces. (Pavitt, 1979).

Beyond the general relevance of the above, we must keep in mind that for those Third World countries seeking to develop an export-oriented industrial base, this relationship does assume much more specific signficance. The possession of a capability to undertake technical change activities (in some cases involving the application of quite sophisticated technologies to traditional areas of production) may now be necessary to achieve/maintain export success - even in sectors where developing countries have traditionally relied on their low wage rates as their primary competitive advantage. (See for instance Hoffman, 1986; and the articles in Hoffman, 1985 (a) and (b)).

The role of technological advance in the world economy

In moving next to the role of technical change in relation to the world economy, we will here make only a brief set of observations. Some versions of the so-called 'long wave' theories link the emergence and diffusion of fundamental technological advances to periods of economic expansion that have characterised the performance of developed capitalist market economies over the last two hundred years

(See Freeman, Clark and Soete, 1982). The innovations involved have been the development of steam power and textile machinery in the 1780s, railroads and the steel industry in the 1840s; electricity, the internal combustion engine and chemicals in 1890s; and electronics, petrochemicals and synthetic materials in the late 1940s. The emergence and gradual diffusion of these innovations throughout the industrialised economies coincides with 20-30 year periods of increasing rates of growth of output, employment, and productivity gains. These periods of expansion have tended to be followed by 20-30 year periods of economic stagnation, recession and depression. This occurs because as these innovations mature and diffuse, they tend to lose their ability to generate high rates of profit and productivity growth. This process results in a slowdown and eventual decline in output and employment growth with the whole process eventually being reversed by the emergence of a new set of 'heartland' technologies. In the context of the current period of stagnation and slow growth in the world economy, much of the interest in the so-called new technologies of microelectronics, genetic engineering and others is fueled by speculation that these technologies could contain within them the seeds of a renewed expansion in the world economy.

Whether or not the next upswing will come, and when it will come, is still a matter of contentious debate, as are the underlying explanations of the long cycles themselves. Nevertheless, the historical links between waves of technical change and cycles of economic expansion and contraction are being increasingly accepted as further evidence of the fundamental importance of innovation as a driving force in world economic growth.

Whether or not the above examples of the impact of technological advance in the developed countries are in any way relevant to the experience and situation of developing countries is of course open to question and debate. Nevertheless, this does not negate the objective importance of the observed relationships between technical change and economic growth within the developed economies.

2. Evidence about Technical Change in the Third World

Fortunately, we do not need to reply solely on the experience of the industrialised economies to make our case. Evidence has also been accumulating about the role that technological advance has played in development in the Third World. The evidence available to us is certainly not as extensive or as comprehensive as the information on the experience of the OECD countries. Nevertheless, it is substantial enough to demonstrate that a sizeable number of Third World countries have been able to develop a significant capacity to undertake technical change activities in a broad range of areas - and on the basis of these capabilities have managed to create in some cases a strong and innovative domestic industry as well as achieving a degree of competitive advantage and international competitiveness in products and sectors where they had none at all to begin with. We shall be drawing heavily on these studies in a detailed fashion in subsequent lectures and here I only want to highlight some of the main conclusions. Again, we can present the evidence at different levels of disaggregation.

National level analyses

Unfortunately, evidence relating to technical change and economic performance at the national level is limited. There are a few studies based, as those dealing with the industrialised economies, on aggregate production function analysis. These studies do appear to show that technological advance, captured through the measurement of the rate of growth of what economists call total factor productivity, has been partially responsible for the recent high growth rates registered by some of the Asian economies - and suggest that countries such as South Korea, Singapore and Hong Kong had a higher rate of total factor productivity growth than the US in the 1970s. The results of such studies, while perhaps indicative of a trend are neither numerous enough nor sufficiently methodologically sound to draw any firm conclusions. This is not the context in which to criticise these aggregate studies in detail - suffice it to say that there are significant methodological problems in using production function analysis to examine TFP growth in developing countries - not least of which is the inherent unreliability and inadequacy of the data base. Nevertheless, it is unlikely that the above results are totally without foundation particularly when one takes into account the evidence of technical change at the sectoral and firm level to which we turn next.

Sectoral level studies

We are, in fact, on much firmer empirical ground when we drop our analysis down to the sectoral level. Here we can point to two types of related evidence. The first is the emergence of major new product innovations developed by locally-owned firms in developing countries in response to the particular structure of demand in local markets. One well-known example involves the case of the airplane industry in Brazil where public sector firms have been able to design a highly successful series of commercial and military aircraft ideally suited to Brazilian air travel conditions. The locally designed and produced planes (11 models and more than 200 sold by 1980) have over 50 percent local content, with many of the local components themselves representing important innovations. The planes are competitive on price and quality grounds with foreign aircraft. Most important of all, these planes are being marketed successfully internationally via exports to OECD countries ($12m in sales in 1979), with more than 75 planes already sold in the US by the end of 1981 (Dahlman, 1982).

Other evidence of strong sectoral performances involving indigenous innovation and often linked to exports has been documented by numerous studies cited in the IDRC bibliography such as Katz and Albin (1978), and Teitel (1981) for Latin America; Mascerenhas (1982) for India; and Amsden (1977) for Taiwan. In these cases, the combined innovative efforts of firms operating in sectors such as consumer goods, mechanical engineering, chemicals, consumer electronics, petroleum refining, and machine tools have lead to formidable rates of growth of domestic and export market share - often in direct competition against foreign firms. These exports have consisted of both final products and technological goods such as process and engineering know-how, consulting services, turn-key plants, etc.

Finally, Dahlman and Westphal (1982) review the experience of South Korea in a number of sectors such as textiles and textile machinery, plywood, shipbuilding and steel production where Korean firms have exploited their traditional low wage comparative advantage in combination with a high degree of efficiency improvements via production engineering to greatly expand their exports to very competitive Western markets. These authors link the success of Korea with the development and deployment of technological capabilities. Moreover, in their discussions they point out that TNCs have had only a very limited direct involvement in this process in most sectors. This point is particularly interesting because it conflicts with the widely held perception that South Korean exports come from sectors where TNCs dominate.

Firm level evidence

Research examining the technological achievements of individual firms is perhaps the most impressive evidence that can be marshalled. Some of the most frequently cited examples refer to steelplants in Latin America. Maxwell's study (1976) of a private sector Argentinian steel company, Acindar SA, documents a consistent stream of internally generated technical improvements that contributed to an annual rate of labour productivity growth in excess of 17 percent between 1966 and 1977, and an annual drop in capital/output ratios of some 14 percent over the same period. Dahlman's study (1978) of the USIMINAS steel plant in Brazil shows how after that plant opened in 1962, it reached planned nominal capacity of 509,000 tonnes/annum by 1966 and then over the next six years had its capacity 'stretched' (via technical change) by over 100 percent to nearly 1,200,000 tonnes with its original equipment and little new investment. Labour/output ratios were increased from 70 tons to 228 tons of steel ignots, and capital/output ratios were reduced from 4.79 in 1967 to 1.39 in 1972. A different sort of success in innovation has been shown by Horatio Vlana's study (1984) of a Mexican firm, Midrex, which has successfully developed a major new steel technology process (direct reduction) which they have exported successfully to a number of countries.

Steel is not the only sector where Third World firms have demonstrated an innovative capability. Dahlman and Westphal (1982) reviews the work by Katz et al. (1978) that examined the experience of Argentinian firms producing rayon, auto components and telecommunication equipment who were able to introduce an impressive array of innovations that lead to new products, improved quality, diversified raw material use, and improved process efficiency. (See also Teitel, 1981). Similar successes are recorded in Asia, particularly in South Korea, where, for instance, SNU (1980) examined innovative efforts carried out in a polyethylene plant which substantially improved efficiency through the 1970s.

The above examples of firm level innovation by no means exhausts the evidence that could be cited. However, before moving on to consider some of these other examples, it may be useful to immediately deal with one obvious qualification that must be appended to the examples already given. This reservation is that the evidence cited above relates to a relatively limited set of countries, most of which are commonly known as the newly industrialising countries (NICs). This bias in our sample certainly poses a problem of relevance since clearly the NIC experience is somewhat removed from the reality facing many other developing countries, whose industrial structure is much less diversified than the NICs and who tend to be much more technologically dependent on foreign countries.

Such reservations are obviously legitimate - but we do not believe that they are strong enough reasons to justify rejecting the relevance of the NIC experience to other Third World countries. One principle reason for this is that the NIC experience establishes that developing countries do indeed possess a substantial capacity for indigenous technological development. Such a proposal of course stands in direct opposition to the still widely accepted 'theories' of technological dependence and the supposed constraints this situation imposes on development in the periphery.

3. The NIC Experience: The Death Knell for Technological Dependency?

While we are on the subject, it is probably worthwhile briefly reviewing the main tenets of the dependency argument since it dominates so much of the discussion in this field.[1] Technological dependency, which is really a subset of wider notions of dependent underdevelopment, posits that developing countries are nearly totally dependent on foreign flows of technology for their means of production. This dependency allegedly grew out of the historical conditions of colonialism, when the particular patterns of demand by the colonial administration for imported consumption goods was passed on to the local elites.

In the post-colonial period, these imported consumption patterns remained, and the technological means to satisfy these were brought in via technology transfer from abroad under the guise of import substitution policies, primarily through the good offices of direct foreign investment by transnational corporations (TNCs). Thus, imported consumer preferences and technologies were seen to have penetrated deeply into domestic economies completely displacing existing modes of production and consumption. In addition, it was argued that the growing presence of TNCs, in alliance with the ruling elites, also effectively prevented the development of local technologies by local firms since these could either not compete (often due to quality features and xenophobia) or else they were actively discouraged by government policy.

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[1] These comments are based on a SPRU mimeo prepared by Martin Bell.

One of the crucial points about this argument is that the existence of current conditions of technological dependence are blamed almost entirely on historical forces/factors which were/are external to the economy. A further corollary of the argument is that the technologies so imported were inappropriate to local conditions - and presumably continue to remain inappropriate. This is presumed to be so because developing countries were thought to lack the necessary technological skill and expertise to generate their own technical solutions. And even where skills do exist, the argument implies that due to dependence on outside sources of technology, local sources have been progressively marginalised and isolated from the sphere of production. Hence the circle is drawn up very tightly - with the end result being that the developing countries are expected to remain technologically static, completely reliant on foreign firms and hence prone to a whole variety of exploitative measures designed to extract surplus from the economy. I have of course characterised and oversimplified the dependency argument a good deal. Nevertheless these are the bare bones of the thesis presented by Frank (1972), Patel (1972) and others. To be sure, these arguments certainly provide a useful analytical framework from which to describe the experience of many sectors in many countries. And the empirical evidence on which they are based also provides an accurate view of reality in some contexts. I therefore certainly do not reject the basic concepts of the dependency argument. But I do question the very rigid way in which these are interpreted in the literature, and the myopic way in which policy makers (and researchers) are so often dominated by a 'dependence' mentality that leads them to place most of the blame for the current technological backwardness of Third World economies on external forces. The only conclusions they often seem able to draw from this reasoning is that they do not believe that any improvement is possible, short of total change in the way the world economy is organised.

The evidence cited earlier shows that this was not the case in precisely those economies in Latin America on whose experience the technological dependency thesis was originally based. What these studies show in fact was that indigenous technological advance did occur within domestically owned and controlled firms. As a result, productivity improved, more appropriate products and processes were developed, and perhaps most importantly, a set of links with local scientific and technology suppliers were established which lead to further intersectoral integration. In short, a particular form of technological dynamism emerged which has continued and has lead, as I mentioned, to some Third World firms establishing a genuinely competitive capacity in major international markets.

I believe that it is very significant that these capacities emerged in countries/economies in which there was a massive TNC presence, which the national government of the day clearly favoured and in which political conditions were in some cases extremely oppressive. For instance, Brazil is one of the economies to which dependency analysts usually refer - yet by 1949, domestic capital goods suppliers using indigenous technology wereable to supply approximately 69 percent of all producers equipment required by the economy.

Even in the technically complex petrochemicals sector, Brazil has demonstrated a substantial accumulation of technological skills. Between 1972 and 1982, the domestically supplied proportion of engineering services and capital goods needed for the construction of a series of three ethylene plants rose from negligible to 61 percent and from 30 to 70 percent, respectively (Sercovitch, 1980). These sorts of example, which can be repeated for other countries, demonstrate the possibilities for technological improvement even in countries in which the particular conditions of dependence seemed to impose severe limitations. Hence even if we reject the direct relevance of the NIC experience for other countries, it at least shows that some change is possible, and points the way forward in many important ways that I shall pick up in later lectures.

4. The Experience of Other Developing Countries

Despite the value of the NIC experience, it would of course be a mistake to assume that only these countries have demonstrated any capacity for indigenous technological development. Many other countries have shown they have this capacity as well. A priori evidence of this comes from the export performance of the Third World in the 1970s. By 1979, some 40 countries (28 non-NICs) were annually exporting over $150 million of manufactured goods. Much of this can of course be related to non-technological factors such as low wages or the involvement of TNCs. But I believe that an increasing degree of technological capability lies underneath this export performance since there has been a gradual diversification of Third World exports away from labour-intensive goods towards more technologically complex products.

There is other evidence of this as well as from both inside and outside the formal industrial sector. In a D.Phil study at SPRU, Nit Chandramonklasri (1985) examined the experience of 20 industrial firms spread across 10 industrial sectors in Thailand for evidence of their ability to improve their efficiency of energy use in response to high fuel prices caused by massive price rises in the 1970s. He found numerous examples of minor and major process innovations which lead to improvements in fuel efficiency of up to 800 percent per unit of output.

Also in Thailand, Bell (1978) examined the experience of the cassava flour industry. In the 1950s, the industry producing cassava flour was characterised by a large number of small-scale, highly inefficient plants. In the 1956-1960 period, three large-scale, foreign-controlled, 'modern' plants that were based largely on imported technology were set up and for which the local equipment industry provided only 6.3 percent of the necessary inputs to establish the plant. Yet by 1965, after a rapid expansion of the export market for cassava flour, Bell discovered that 15 new plants had been established. Most of these new plants were set up not by foreign enterprises but by local entrepreneurs who turned to local input suppliers to provide 75 percent of all the capital equipment required. Moreover, the capital/output ratios for these plants (over the earlier vintages) had declined by 50 percent, the quality of the final product was greatly improved, and the labour intensive nature of the new plants generated considerable local employment. This example is particularly interesting since it is taken from a country which at that time resembled many of the poorer countries of the present period - a small economy, heavily dependent on agriculture, with a small agro-processing industry, and whose 'capital goods' industry was primarily composed of simple workshops for metal fabrication.

Similarly impressive evidence on innovative capability in non-NIC countries is documented in a recent collection of case studies carried out in the Middle East (Bell, 1986). Malkawi (1986) studied the effects of the public sector Jordanian Phosphate Company to improve its efficiency and overcome severe design faults in foreign (mainly British) supplied processing equipment. The technical changes introduced by the company are very interesting because the variety of changes matches the sort of improvements carried out by firms in more advanced countries.

A completely different type of example, this time involving product and process change, is discussed by Fattah (1986). This describes the evolution of a small private sector Lebanese producer of commercial and domestic refrigerators. Over two decades the firm completely absorbed imported refrigerator technology and was able to design and produce its own products that competed very successfully on quality and price terms against untaxed foreign imports in the totally open Lebanese market. The firm produced nearly 80 percent of its component requirements and designed and fabricated virtually all of its process equipment. In 1979, it submitted a tender to set up a refrigerator factory in Iraq in which it was competing against all of the world's major refrigerator producers - Admiral, Sunbeam, etc. The firms' bid was 11 times below the lowest bid of the big manufacturers, for a factory whose output would be suited to the Iraqi market size, yet whose unit costs were equivalent to those estimated by the large firms who planned to construct a much larger capacity plant in order to achieve scale economies that could only actually be realised via exports.

If one cares to look there are many other examples of technical change occurring in small economies - particularly once you move out of the formal sector into the performance of the informal sector. Here one can find an abundance of evidence of the ability of firms/entrepreneurs, working with very little in the way of equipment and capital, to produce highly innovative products and technical solutions to problems under the most adverse conditions. The appropriate technology literature abounds with these examples - Thoburn (1973) on the Malaysian engineering industry; King (1974) on metal workers in Kenya; Muller (1980) on blacksmiths in Tanzania; Sanson (1979) on a motor pump innovation in Vietnam and Jecquier (1976) who provides an extensive series of examples of the existence of a pervasive technical change capacity in even the poorest Third World countries. Clearly these capacities are at a very much lower level than those in the NICs; they are much more ad hoc and more often than not have not led to the kind of self-sustaining technological dynamism evident in the NICs that we believe is so important for independent development. But they certainly do exist.

5. Some Important Qualifications

Before moving to explore the implications of the evidence just presented, I must first make some very important qualifications about the generalisability of these experiences. First, as impressive as these examples are, and despite the fact that we could cite many more, unfortunately the painful fact remains that they are relatively minor exceptions to the reality found in the industrial sector of most developing countries. This reality is only too well-known. Most poor countries do not possess a thoroughgoing innovative capacity - indeed many do not even have the critical minimum levels of skills necessary to successfully operate the production facilities already in place. As a result, technological dependence is still very widespread and in some cases is getting worse.

Secondly, even where innovation does occur we must be very careful to point out that (a) the innovation process does not resemble what happens in the developed economies, it is much more ad hoc and sporadic; (b) the rate of improvement in efficiency that does occur is often far below that which is theoretically achievable; (c) observable bursts of growth in efficiency are often preceeded by years if not decades of zero, or even declining, productivity growth and the resultant high social and private costs of this phenomenon.

Thirdly, I am particularly concerned to stress that both in cases where there is and where there isn't evidence of technical change and productivity improvement, we must be careful in attributing these conditions solely to the existence or lack of existence of an indigenous technical change capacity. Many other factors can intervene. In the cases of success, the ability of the firm to translate technical change into measureable economic gains depends also on luck, good management skills, favourable government policies, market size and many other variables. (See Teitel, 1981b for a good discussion at this point).

Fourthly, many Third World firms succeed in surviving and making a profit very often without affecting any technological improvements at all. Thus, the existence of technical change capacities is neither a necessity nor a sufficient condition for commercial success - particularly in the highly protected markets characteristics of most Third World countries. (See Bell Scott-Kemmis and Satyarakwit, 1982 on this point). Likewise even when the necessary technological resources do exist, the illogicality, illegality and institutional rigidity of the firm's environmental operating conditions may simply choke off and stop dead any effort to use these resources effectively. The well-known example of public sector enterprises, whose undoubted capacity to stimulate economic growth and technological improvement, yet whose operation is subject to the whims and interference of government bureaucrats, is a case in point.

Nevertheless, despite all of these qualifications, let me underline the relevance and permanence of the basic themes highlighted by the empirical evidence I have presented. First there is a demonstrable link between technical change and economic performance in Third World countries at the level of the firm, the sector, and the economy. Second, it is possible for firms, operating under extremely adverse conditions, to accumulate the technological capacities needed to effect technical change. Thirdly, firms operating in countries at all levels of development possess the capabilities for technical change. And finally, developing countries will only benefit substantially from the use of technology when they have the capacity to ensure that that technology can be made suitable to their requirements and can be continually altered and improved to take account of constantly changing conditions.

6. The Need to Make the Case to Policy Makers

It may appear that all of the above evidence adds up to a pretty strong case for Third World governments to develop positive policies designed to support local innovation. Unfortunately this is not yet the case in many countries, and the importance of accumulating indigenous technical change capabilities is simply not recognized in policy formulation and implementation. I think this failure of recognition on the part of the policy makers is one of the most critical problems that professional researchers and the developing world in general face today. There are three reasons for this point.

First, I believe that one of the reasons why the current world economic crisis is creating so much suffering and chaos in the Third World is because developing countries lack the technological capacity to respond to the crisis in ways which mitigate its worst effects. Just one example of this is the appalling situation that exists as regards the low levels of capacity utilisation in the industrial sector. Severe foreign exchange shortages throughout the Third World are preventing the importation of the spare parts and intermediates necessary to keep industry operating. As a result, capacity utilisation is probably below 30 percent in all but a few countries. Being unable to operate factories at minimum levels of capacity of course has severe direct and indirect 'knock-on' effects on the economy. Certain basic consumer goods cannot be produced and therefore people have to go without them; factories close down because they cannot operate and people are put out of work; the goods that are produced are very costly to the economy; and exports are lower than they should be and so foreign exchange earnings are further reduced - thereby worsening the overall situation. Yet in many cases the spare parts and intermediates necessary to keep the factories going could have been produced locally (or regionally) if governments had conciously pursued policies designed to generate the necessary indigenous capacities to produce these imported items. If such policies had been followed, then many (but of course, not all) of the problems currently arising from low capacity utilisation in the poorer countries of the Third World would have been much less.

Secondly, in addition to the problems caused by the existing gaps in technological capacity, a whole series of radical innovations have emerged on the horizon which could cause the technological gap between the First and the Third World to grow even wider, with even more severe consequences for developing countries in terms of their ability to compete and survive in or out of the international division of labour. Unless industrial and developmental policies are formulated and implemented which take account of these potential changes in the technological basis of production, even the ability to survive of those countries who have already achieved a measure of technological development must be brought into question. It is going to be an even tougher ball game in the future than it is now - and the reasons for this are largely rooted in technological change.

Thirdly, there appears to be a new, concerted and coordinated attack upon the role of the state in Third World economies. The sources of this attack are the international financial institutions such as the IMF, the commercial banks currently playing such a key role in propping up bankrupt developing countries, OECD governments, particularly those of a more conservative disposition, various international and bilateral aid agencies, TNCs as well as various distinguished members of the development profession.

The objective of their attack is to roll back what they see as an excessive degree of state intervention in the economy - through the public sector and through various other institutional and fiscal mechanisms such as, for instance, the systems of protection which exist to support ostensibly 'infant' industries. They aim to replace state control of the economy with the discipline of market forces. The reasons for this attack are both pragmatic and political.

Throughout these lectures, the reader will note that I am extremely critical of the various modes of intervention adopted by Third World governments. This criticism extends not only to the ineffective use of protection to stimulate the growth of protected industries, but also to the many ill-advised attempts to institutionalise science and technology through the creation of National Science Councils and industrial research institutions. I also believe that efforts to eliminate the excesses associated with technology transfer such as monopoly pricing, "packaging", and restrictive contractual clauses via, for example, the establishment of registries for vetting technology transfer contracts has often been ineffectual and a diversion of effort and scarce resources.

However, equally I do not believe that a retreat to the rigours of the market is the best and only means of developing indigenous technological resources. As I will try to show in subsequent lectures, there must be some form of state intervention in this area - but this must be quite different from the approaches currently being followed by many countries.

So for all of the above reasons - the failure of policy makers in both the public and private sector to pursue strategies for the development of technological capabilities is a very big problem. Moreover, the reasons why technical change and the accumulation of capabilities are not on the policy agenda in most countries are legion.

As noted earlier, policy makers simply may not be aware of the role that technological advance plays in the process of economic development. They tend to be more concerned with increasing the size of the capital stock which is what theory and the textbooks tell us is a key determinant of economic growth. It may also be the case that policy makers do not believe that independent technological development is possible or necessary in their own economies and that hence there is no need to do anything to promote it. Such a perception is as likely to emerge from those with a 'dependency mentality' who believe that conditions are so bad that nothing can be done; as it is from those who believe for pragmatic or theoretical reasons that nothing should be done - either because they see industrialisation as a process in which technology is an exogenous variable and that technical improvement happens more or less automatically with no need for state intervention, or because they believe that investments in technical change (i.e. investments in R&D) should not be undertaken by developing countries who do not possess any inherent advantages in this area but should be left rather to the developed countries who do possess these capabilities. In this situation the policy prescription has been that developing countries should simply import (via unrestricted technology transfer) the best that the developed countries have to offer - thereby bypassing all of the difficulties actually involved in R&D. Explicit in this view is the belief that this technology transfer should take place strictly within the private sector with no restrictions/ interventions from government.

It is important to note that these perceptions have their roots in neoclassical economics - a set of arguments which many reject because of the totally unrealistic assumptions on which they are based. Yet it is not sufficient in this context simply to criticise these views, as this is unfortunately the dominant paradigm within which most policy makers operate. Rather we need to make the case on their own terms and with their own arguments.

Even without such theoretical clashes, it should also be obvious that persuading policy makers to invest in the creation of indigenous technological capabilities is likely to be a very difficult task in the current economic climate in most Third World countries. Merely claiming that technical change and technological capabilities are "good things" (like patriotism and apple pie), or pointing to their importance in other countries is not enough. The resources available for investment in developing countries do have opportunity costs. Thus, those who argue the case for investing in technical change related activities must be able to quantify the returns to these investments and show how and why they are higher than for other uses for these resources. This may be particularly important for the short run because of the short run costs of intervention - i.e. giving opportunities to local firms to improve on imported technology or subsidising R&D - are likely to be both expensive and risky from the perspective of the private sector user of local technology. Local suppliers will inevitably make mistakes, offer low quality, fail to meet delivery times, etc. In light of this and without the possibility of compensation from the state, local user firms will not contract with local suppliers, and will prefer instead to rely on 'reliable' foreign sources of supply.

Moreover, even if subsidies are made available and even if the firms do improve their technological skills over time, it is very difficult to estimate the scale and the time frame over which these benefits are likely to accrue. We have gone some way toward understanding technical change processes in the Third World - but the analytical tools available to us are as yet inadequate to cope with the need to provide a rigorous justification for our case. Hence it is simply very difficult to predict where and how X dollars of training or support for R&D will produce Y benefits 10 years from the time of investment. To make matters worse from the policy makers perspective - particularly if he/she is in a politically visible position - such long term benefits to the society are inevitably very heavily discounted. Short term visible results are what count in the struggle for the allocation of resources.

I want to close here by again emphasising a point I made at the beginning of this lecture - one of the principle objectives of technology policy research must be to provide the evidence necessary to persuade policy makers of the need to take a more aggressive stance vis-a-vis support of the development of a capabilities to effect technical change - by identifying where technical change is occuring (or should be), by demonstrating the benefits arising from it and/or by illustrating the costs incurred by firms, individuals, and society as a whole by their future fail to invest in the creation of capabilities to effect technological advance.

LECTURE TWO

TECHNOLOGY, TECHNICAL CHANGE AND INDUSTRIAL DEVELOPMENT: SOME BASIC CONCEPTS

Introduction

Lecture One attempted to marshall the available empirical evidence to demonstrate the central role of technical change in the process of economic development and industrialisation. I was, of necessity, rather eclectic and empiricist in that presentation. In this lecture, however, I want to step back a bit from the empirical detail and discuss some of the theories, conceptual tools and analytical approaches that researchers in the technology and development field have developed over the years to explain and analyse empirically observed relationships between technological progress and economic advance. In the course of doing this I want to introduce some of the key concepts and concerns that I will be using or relying upon both implicitly and explicitly throughout this set of lectures.

I start in Section 1 by giving a brief description of the treatment of technical change in the mainstream economics or neoclassical literature. Section 2 presents an alternative conceptualisation of the role of technology in a market economy based on the work of Schumpeter. Section 3 builds on this analysis to introduce our core set of concepts that form the conceptual basis.

1. The Treatment of Technical Change in Conventional Economic Analysis

Mainstream economics is dominated by a school of thought which accepts the centrality of the "neoclassical" model of the economy. The primary concern of the neoclassical approach is to illuminate the equilibrium relationships between static economic variables (prices, output, profits etc) and the smooth functioning of the economy as it follows a path of balanced growth. The central components of what has been called the "vision" of neoclassical economics are the aggregate production function, perfectly competitive markets, and the instantaneous adjustment of factor prices. It is the interaction of these components within a strictly defined set of behavioural parameters that facilitates the smooth and continuous adjustment of the economy towards its "natural" position of general equilibrium.

The important point to note given our particular concerns, is that within the neoclassical paradigm the role of technical change as a motor of economic development was not recognised at all. Technology was taken as a given element for both the firm and the economy as a whole. Firms were assumed to be faced with an existing production system or range of techniques - sitting ready and waiting to be used like boxes on a shelf. Each technique consisted of a specific combination of (undifferentiated) inputs of labour and capital that when combined produced a given level of output. This range of techniques was conceptually "defined" by a production function. This production function represented all the possible existing and future combinations of labour and capital needed to produce a given level of output. It was further assumed that when a firm decided to enter into production, it would choose from the shelf of techniques (ie the production function), the specific technique that was most appropriate, to its own circumstances in light of the prevailing prices it had to pay for labour and capital. In the neoclassical model the firm was always able to make the correct or optimal choice of technique because it had a total (perfect) understanding of the economic and technical characteristics of the range of techniques from which it had to choose. Moreover, this decision was assumed to be made instantaneously and without the firm itself incurring "selection" costs of any kind.

There are many curious things about this way of viewing the world that could be subjected to severe criticism. Indeed there is a massive and long standing body of serious analytical literature that attacks neoclassical theory from virtually every aspect. However as our concerns are with the technology variable I want to emphasise only two of the unusual characteristics of the model. The first is that in this model the firm (choosing the techniques) is simply a user of fixed production systems. The economists who developed the neoclassical model did not envision that the user firm had any interest, any capabilities or any need to be involved at all in the development of the specific techniques it was to use. These were simply assumed to be made instantly available (fully perfected) to the user as if they were "manna" from heaven.

The second point to note is that when neoclassical economists depict a new situation where the firm is able to produce either the same or more of an output with fewer units of labour and/or capital, they simply assume that a new set of techniques (ie a new production function) would automatically become available to the firm. Once again no attention and no significance is given to the matter of where these new techniques (or new ways of doing things) originated.

The second distinction involved shifts of the whole production function whereby you get increases in output that stem entirely from a new set of factor combinations. This shift in the production function is described as technological change. In the earliest formulations of the model, economies/firms were thought to move onto a new production function in response to massive wage increases paid to the labour force. Hence these shifts in the production function (ie technological change) usually came to be associated in the neoclassical formulation with unit cost reductions in the use of labour. In contrast to movements along the production function, a shift in the production function did actually involve an entirely new way of doing things such that factor productivity was improved.

From our perspective, the most worrying problem with this way of conceptualising the nature of technology and technological change is that it assumes that these are in a sense exogenous to the functioning of the economy. Thus this formulation is totally at variance with the enormous bulk of empirical evidence (some of which was reviewed in Lecture One) which in fact demonstrates the absolute centrality of the phenomenon of technological change. More importantly, no account is given of the sources of technology and technological progress, of various types of technology and technical change that exist nor of the mechanisms that lead to technical change and the diffusion of these changes through firms within an economy. Instead the main sources of economic growth are assumed to be through augmenting stocks of labour and particularly capital. It was/is this perception (that growth derived from increases in the capital stock) that underlays much of the early emphasis in development economics on the need to maximise the rate of new investment by importing ready made systems of production from the industrialised countries.

Of course the above discussion is an enormously over-simplified presentation of the neoclassical model. There have been numerous attempts by neoclassical economists to "improve" the treatment of technology within their models in an attempt to bring these a little closer to demonstrated reality - particularly in light of the persuasive arguments that have been made against the model's internal theoretical validity (as presented most clearly in the classic critique made by Kennedy and Thirwall, 1972). Many of these amendments have either involved attempts to embody technological change in the investment process as a source of productivity increase - as either capital embodied innovations or as a function of the scale of investment (See Arrow, 1962); - or to link R&D expenditure to investment by seeing it (R&D) only as a means by which the profit maximising firm is better able to meet the performance criteria of the general equilibrium (See Eltis, 1971 for the best presentation of this approach).

However in the end, these attempts by neoclassicists to refine their "models" are (as Arrow, 1962 himself notes) primarily defenses of the production function approach. They fail as noted above to explain the origin of technological change, its nature and factor bias, the rate at which it occurs, the costs involved in generating it, and the mechanisms by which this occurs at the level of the firm, the sector and the economy.

Now it may be that this latter set of factors are in some curious sense not a "legitimate" concern for neoclassical economics with its exclusive focus on static equilibrium within a fully developed market economy. However, given the sheer weight of the evidence pointing to the importance of the technological factor in the industrialisation process, we are forced therefore to look elsewhere for a model which first adequately explains the observable phenomenon, and more importantly provides some pointers towards the realm of policy.

2. Schumpeter's Contribution

I believe we can find a much more useful set of concepts and insights into the role of the technological factor by considering briefly the analysis of these issues carried out by the German economist, Josef Schumpeter, who probably has done more to introduce the reality of technological progress into economic thinking than any other economist since Marx.

In a major departure from the mainstream of economic analysis in his day, Schumpeter instead of seeing technology as a exogenously determined static variable with no influence, in fact viewed the process of technical change as the principle motor driving the functioning of a market economy. For him, technical change was endogenous to the economy; indeed firms introduced new ways of doing things (improved techniques) or new products explicitly because it gave them an advantage over their competitors in the market place. The new product or lower cost production method would allow the innovating firm to reap extra (or super-normal) profits over and above that of its competitors. Thus Schumpeter placed technical change at the very heart of the forces governing the laws of competition in a market economy.

Schumpeter saw this mechanism operating in a dynamic way, since he recognised that innovating firms in a competitive economy could not hope to permanently secure extra profits from the innovation. This was because a competitor would in time be able to imitate the first innovation and thus by selling the resultant product at a slightly lower price would be able to whittle away at the super-normal profits of the original innovator. This decline in the rate of profit would however, in Schumpeter's model, soon be interrupted by the introduction of yet another innovation/technical change thereby causing the whole cycle to begin again. For Schumpeter this process of - innovation - super-normal profits - imitation - profit reduction - innovation - was continuous and happened throughout all major sectors in the economy; and meant that the economy was in a constant state of disequilibrium rather than always tending towards the equilibrium of the neoclassicals. In the classic statement of the mechanism Schumpeter argues that:

> "the capitalist economy is not and cannot be stationary. Nor is it merely expanding in a steady manner. It is incessantly being revolutionised from within by new enterprise, i.e. by the intrusion of new commodities or new methods of production or new commercial opportunities into the industrial structure as it exists at any moment. Any existing structures and all the conditions of doing business are always in a process of change. Every situation is being upset before it has had time to work itself out.... Possibilities of gains to be reaped by producing new things or by producing old things more cheaply are constantly materialising and calling for new investments. These new

> products and new methods compete with the old products and old methods not on equal terms but as a decisive advantage that may mean death to the latter. This is how "progress" is brought about in capitalist society. In order to escape being undersold, every firm is in the end compelled to follow suit, to invest in its turn and, in order to do so, to plow back parts of its profits, i.e. to accumulate. Thus, everyone else accumulates" (Schumpeter 1961).

Schumpeter's analysis provides a substantially more realistic explanation of the role of technology and its impact on firm behaviour in a market economy than the explanation offered by the neoclassicals. However if we examine Schumpeter's model closely, it becomes clear that his analysis also had some severe limitations. First of all he was only interested in "big" technical changes - ie in what neoclassicals would call shifts in the production function. He saw these technical changes as being of fairly momentous import and significance and believed that they were therefore discontinuous events associated with the investment process. He believed that the technical changes themselves originated with inventors who carried out an R&D function that was normally separate from the business of production. These inventions were put into commercial use by the innovator firms; and for Schumpeter it was the innovating firm (or rather the entrepreneurs who in his search for profit was continually seizing upon the products of the inventors) who was the "hero" of the capitalist economy. Thus his analysis was primarily concerned with what happened after the original invention was commercialised (introduced into production by the entrepreneur).

Consequently we can see that even in Schumpeter's approach, though he recognised technical change as endogenous to the economy, there is no real analysis of the nature of inventive activity; or where and from what sources inventions arose. Indeed even in Schumpeter's concern with events after the invention is commercialised, his view was that the process of imitation that ensued was precisely that, exact copying, by the imitating firm of the original invention; and by extension, his concept of the process of diffusion was formulated rather simplistically as only involving the movement of the original invention from firm to firm. He did not actually envision that the imitating firm in any way engaged in efforts to make technological improvements on the original invention.

The above comments suggest that Schumpeter's approach, although representing a major and fundamental improvement on the neoclassical view of the world, does have its limitations. Nevertheless, his views have been enormously influential and have fostered a substantial and illuminating body of theoretical and empirical study which has sought to illustrate the central role of technology in the economy. Much of this early work was carried out by the economists and economic historians mentioned in Lecture One such as Nathan Rosenberg, Chris Freeman, Stuart Hollander and John Enos. Their work and that of others has introduced far too many refinements to Schumpeter's model and therefore to our conceptual understanding of the technology factor to be reviewed here (though many are discussed in Freeman, 1974 and Rosenberg, 1976 and 1981). Rather than discuss each, I want to simply summarise some of the main findings from this body of work and urge you to consult the literature for further details.

(a) Research has led to the (still contested) view that the accumulation and application of experience- based technological knowledge in fact frequently preceeded the development of scientific knowledge in many fields; and thereby led to scientific discoveries and indeed to the development of some scientific disciplines. This cause/effect relationship of course contradicts the common presumption that technology is the mere application of prior scientific knowledge.

For instance, the science of metallurgy began to develop in the second half of the 19th century largely in order to account for the behaviour of metals already being produced by the Bessemer and post-Bessemer steel technologies. Even the scientific research underlying the so-called "science based industries" such as electronics benefitted from the stimulus provided by practical industrial experience. Scientific research which led to the development of the transistor effect was undertaken in an attempt to understand the behaviour of semi-conductor materials such as copper oxide and silicon rectifiers which had been discovered and developed by purely empirical means and were already in industrial use years before the transistor effect was "discovered" in 1947.

(b) Research also firmly established that, historically, much technological progress (indeed from as early as the end of the 19th century), has in fact originated largely within the producer firm as a result of organised R&D efforts undertaken by the firm to improve its products and processes. Research into this topic made it clear that the role of the individual inventor (much loved by Schumpeter) as a source of technical change for firms has declined substantially since then.

(c) Following on from this shift in the perspective (i.e. from viewing the firm as opposed to the individual/scientist as the chief source of technical change), the role, function and impact of corporate R&D has been the continual focus of policy research. This work has subsequently demonstrated that a good deal of the R&D carried out within the firms is actually biased towards applied research efforts that rely heavily upon applied engineering disciplines rather than the skills of the scientist involved in "basic" research.

(d) Furthermore, while formal organised corporate R&D programmes have been found to be particularly important in achieving major technological breakthroughs, it is now also accepted that minor or incremental technical change has been responsible for much of the observed improvement in productivity at the firm and at the aggregate level (such as that recorded by Solow, Dennison and others). Such incremental technical changes can be viewed as improvements to existing equipment, processes and techniques that are of a relatively minor nature compared to the scale of change and the costs involved with major investments in new capital stock.

A good example is the Enos study of dynamic technical change in the US petroleum industry, cited in Lecture One which detailed technical change related increases in productivity such as an increase in capacity from 9 barrels/day to 36,000/day; 98% saving in labour costs, 80% in capital costs, over 50% in material costs/unit of output. Enos' work suggests there are significant differences between the types of technical change that occurred in the industry over that period and he places a good deal of emphasis on the much greater importance of minor technical change as a source of the above mentioned productivity increases (Enos, 1962).

Enos distinguishes between the "alpha" and "beta" phases of technical change in petroleum refining. The former covers the invention, development and innovation (the first commercial introduction) of basically new processes. The latter covers the subsequent improvement of those basic process innovations. The beta-phase includes not only "learning" within any one plant, but also the series of improvements which result from building incrementally more efficient new plants embodying the same basic process.

> "the beta phase is as significant in its economic effects as is the alpha. There appear to be greater reductions in factor inputs, per unit of output, when a process is improved than when it is supplanted by a better one."

Enos' findings have been confirmed by Hollander, 1965, Gold, 1975 and many others and have convincingly established the point that minor technical changes, involving alterations to existing processes and equipment, are a significant and major source of productivity improvement and are in no way less important than more radical technological breakthroughs.

(e) In highlighting the importance of minor technical change, the literature drawing from the experience of the industrialised countries underlines the related point that many of these minor improvements do not emanate out of the R&D lab - but instead come from a wide variety of sources within the firm - from the machine shops, from production workers, from efforts at quality control, from improved instrumentation, as a result of maintenance and trouble-shooting activities, and so on. The argument made is that the knowledge of the characteristics and constraints of the existing production system generated by all of these activities has frequently been used by engineers and technicians working within the firm to effect relatively small but cumulatively significant technical improvements. From this perspective, technical change can be seen to occur throughout the entire productive enterprise and therefore, a priori, successful improvements are as likely to arise from maintenance activities as they are from the R&D labs. Likewise, there is the implicit point that the range of skills that can be drawn upon to effect technical change within the firm extends far beyond those of the R&D "scientist" and rests particularly heavily on engineering disciplines of various types.

(f) The sorts of minor and major technical change that take place within firms are not simply associated with reduction in labour cost per unit of output but also result in a multi-dimensional effect on various aspects of factor use and performance such as the reduction of materials use, saving of energy, improved capacity utilisation, higher throughput rates, improvement in the quality of inputs used, products, etc. And rather than simply affecting one parameter at a time, a single technical change event frequently involves improvements on many of these fronts simultaneously.

(g) Finally, it has now become clear that the movement of a technical change from invention to innovation to imitative diffusion (in the Schumpeterian sense) frequently takes a very long time and is in no sense an instantaneous process. Moreover, the process usually involves each successive firm in making changes to the original invention in order to fit its own particular circumstances. Hardly ever would they do this through simple imitation - firm circumstances vary widely, and change too frequently for one invention to suit everybody's needs. Therefore there is an ongoing process of technique-specific technical change occurring as the new technique diffuses through the economy. Thus technical change was perceived to be continuous and occuring throughout the "life" of the product and/or process.

There are of course many other elements that could be included in the above list which draw on empirical research carried out in the developed countries and have enriched our analytical understanding of the technical change phenomena - about the relationship between innovation and firm size, trends in scale economies, differences across sectors and many others. My aim in presenting the above selected set of examples has been simply to give some idea of the way in which empirical research at the firm level carried out within the Schumpeterian tradition has given us a bundle of insights that provides a much more realistic and workable conceptualisation of the process of technical change, its relationship to firm behaviour and economic growth, than that provided by the neoclassical model - one that is not restricted to large firms, the province of state-supported R&D labs and major technological breakthroughs, but emphasises instead the importance of incremental technical changes that can literally take place at any point in the production process or within different types of firms. What we now have is a picture of a non-linear process of innovation that is infinitely more realistic that the static perspective imposed by the neoclassical model and more importantly provided researchers and analysts with a starting point from which to generate a much more useful set of policy relevant insights into the rate of technology in Third World development.

3. Technical Change in the Third World

I would now like to shift the focus of the discussion towards issues related specifically to the role of technology and technical change in the process of industrialisation in the Third World. To do this, we need to start by introducing a few fairly straightforward definitions regarding the concepts of technique, technology and technical change upon which I will rely throughout the rest of this series of lectures. There is a great deal of confusion in the literature with regard to definitions of these terms and many analysts offer differing and even contradictory interpretations. As it is not possible here to sort out all this confusion, I shall simply follow closely the conventions developed by Bell in a number of recent publications (Bell, 1982 and 1986; Bell and Hoffman, 1981, Bell, Scott-Kemmis and Satyarkwit, 1982; Bell, Ross-Larsen and Westphal, 1984).

Thus I start with a definition of "techniques" as meaning "utilised methods of production" that relate to the production of a specific product at a specified volume of output. This notion of techniques differs from that of most economists who tend, as we mentioned earlier, to define a technique in terms of the economic relationship between inputs of undifferentiated labour and capital needed to produce given output. Instead, in our terms, a technique refers to a physical phenomenon - to the particular configuration of different types of equipment, materials requirements, operating procedures, and labour inputs (of all types) necessary to produce a specified level and type of output. From this perspective, the technical specification of a production system or technique (even a simple one used to produce a simple product) can in fact as Bell, Scott-Kemmis and Satyarkwit, 1982 point out, be quite detailed and were they to be written down would easily run to several volumes of drawings, equipment lists, schedules, specifications, operating manuals and so on.

The next definition I wish to introduce relates to the concept of "technology". In the literature this word is used to refer to many different things - some analysts use it interchangeably with technique; others see technology as being composed of a set or a series of techniques. I shall use the term technology like Bell to refer to knowledge - or more precisely to a body of knowledge about techniques. Such a definition, though simple, encompasses a great deal - it obviously implies knowledge already embodied in techniques and the specific elements of which they are composed, but it also incorporates knowledge of the principles underlying the creation of techniques and the knowledge necessary to improve or change techniques.

Thus, the concept of technical change I will be working with in this set of lectures follows directly on from this and refers to both the creation of new techniques and to a change in the technical specifications that define an existing production system, its components and their relationship to each other, the input mix, process parameters, product characteristics, and so on. Therefore throughout this series of lectures we shall be using the term technological capacity to refer to the "stock" of human and institutional resources which are required to create and change techniques of production.

Forms of technical change and its external environment

As with the work carried out on the industrialised countries, research into the process of technical change in the developing countries has identified a range of forms that this phenomenon can take. We can group these into three broad categories:

(a) technical change that involves the introduction of new techniques (product and process) into the industrial sector by means of investment in new plants (what Bell, 1982 calls "technical change that broadens the industrial base of the economy");

(b) the incremental improvement of existing techniques by affecting technical change to established production systems and products;

(c) the generation of new knowledge through basic research whether carried out in separate R&D institutions or within enterprises themselves.

Now while these broad categories apparently encompass much of the technical change activity attributed to industrialised countries, in fact there are some significant differences both in the external and internal environment in which technical change occurs within developing countries and by extension in the relative importance of the different forms that it takes. In terms of the external environmental conditions three stand out as being particularly important. First, because of the general lack of scientific infrastructure, and because of the usually very weak links between the science system and the productive system, basic research or R&D whether carried out within firms or in universities or in centralised R&D institutes plays a relatively unimportant role as a source of technical change in the developing countries. Thus despite the emphasis which international agencies and the scientific establishment in the Third World place upon the importance of science and the science system, its contribution to improving the performance of industry in the Third World has been minimal.

Second, generally in the Third World, government plays a particularly important role in determining the macroeconomic context in which the innovation process occurs. Thus the existence of protected markets for final products influences the nature of the innovative efforts firms undertake; so too does government restrictions and/or incentives relating to imports of raw materials, intermediate capital goods, technical assistance and of course, entire production facilities.

Thirdly, perhaps the most important difference is that a very large share of the industrial production facilities in developing countries are based on the use of techniques imported from the "industrialised" countries.

This last characteristic of the environment of industrial production in the Third World in turn has been found to have direct implications for the nature of the process of technical change that has been empirically observed by policy researchers such as Sercovitch, Teital, Dahlman, and Maxwell:

(a) Imported techniques are rarely introduced into the local economy without some form of adaptation to the local environment and factor price and supply conditions. Inter alia this has been found to involve adapting imported production systems to different infrastructural conditions (vis energy and water supply, transport, etc), different standards of raw material availability and lower quality intermediate inputs, different product requirements for the local markets, etc., etc.

(b) Another significant implication of the reliance on imported techniques is related to the scale factor. Frequently the imported production systems are either scaled down to meet smaller market demands; are operated at much lower capacity than originally designed for; or, alternatively, are required to produce beyond design capacity and average scapping age because of various constraints inhibiting firms from investing in the creation of new capacity.

Taking the case of down sized plants, research has found that plant scales in much of Latin America are much lower than in the industrialised countries. Therefore automobiles are assembled at 20-100,000 units/year, machine tool firms produce 100-500 units per year, a petrochemical plant for polyethelene would operate at between 10 to 120,000 tons/year. Yet industrial firms in the industrialised countries producing similar products would normally be 5 to 10 times larger. These differences in plant size involve many differences in the techniques used. For example discontinuous as opposed to continuous automated processes are used; simpler, more universal and lower capacity machinery is used; and the output mix is more diversified. Thus the firms in developing countries start with a different physical configuration of their techniques to firms in the industrialised countries ostensibly using the same technique.

They therefore almost inevitably follow a different path of technical change. For instance a more discontinuous process inevitably means more downtime as individual bits of machinery break down - this means more time is devoted to generating technical changes that help to alleviate bottlenecks.

By the same token, scale limitations due to investment constraints have forced many firms to explore different means to expand capacity within severe financial limits. These efforts in expansionary technological change have come to be known as "capacity stretching" in the literature and form a particularly important category of technical change - indeed much of the evidence of productivity improvements in both developed and developing countries cited in Lecture One have resulted from various forms of incremental technical changes known as "capacity stretching" improvements.

(c) Finally, and at least partially related to the scale factor and the capital constraints inherent in Third World economies, incremental technical change has been found to be a relatively more important source of productivity improvement in certain types of production activities in the Third World than investment in the creation of new productive facilities. Such incremental changes involve such things as trouble-shooting, minor expansions of capacity, changes in operating procedures, redesign and rebuilding of installed equipment, instrumentation and standardisation, etc. We referred to many of the studies which documented the significance of these incremental technical changes in a variety of industries in Lecture One.

4. Sources and Resources for Technical Change: The Role of Learning in Accumulation of Technological Capability

The importance of incremental technical change as a source of continuous productivity growth in developed and developing countries is reasonably well documented. However, this evidence raises the question of precisely how firms are able to achieve this continuous growth in productivity in the absence of major investment in the creation of new plants and equipment. Traditionally, the economics literature has referred to observed increases in productivity in plants with ostensibly fixed facilities as "learning" - or more precisely as "learning" by doing. The concept was developed on the basis of a series of classic studies that observed the experience of aircraft assembly in the US. It was observed that a substantial reduction in unit costs occurred at the same time that output was increasing. Labour input (amount of time spent on assembly jobs) appeared to fall by 15-20% every time that output doubled with both labour and machinery investment held constant. Similar trends were discovered in US shipyards where firms were able to increase output at a rate of about 28% per year in line with a similar decline in labour input (Bell, Scott-Kemmis and Satyarkwit, 1982, have reviewed these and other studies).

The dimension of the concept of "learning-by-doing" based on the above studies that we want to bring out is the assumption that the observed productivity increases arose out of the experience of production itself. As Bell, 1982 has pointed out this concept of "learning by doing" has three quite remarkable characteristics:

(a) it takes place quite passively with no explicit action required on the part of management, and has been frequently attributed to improvements by workers in the efficiency with which they performed their tasks;

(b) such improvements take place automatically. Hence given enough time and enough output, it is assumed that reasonable improvements in productivity would eventually occur.

(c) these improvements are also seen as a costless by-product of production
- no additional investment in new equipment or training of workers is required.

Somewhat surprisingly perhaps, this notion of learning by doing though originally coined in relation to the experience of industrialised countries has come to have quite an important influence on the debate about policies for Third World industrialisation. For instance, the concept provided an important component of the arguments relating to the development of "infant industry" in the Third World. More specifically it provided the rationale for "protecting" infant industry from the rigours of international competition via trade barriers. The argument made was that protection is allegedly required to allow firms the opportunity to build up experience in production - given this opportunity the firms will "learn" to be more efficient and competitive and in time, levels of protection can be lowered as the infant industry grows up. No other intervention on the part of the government was deemed necessary (i.e. subsidies) and indeed it has often been argued that the learning period averages approximately 7 years, after which time, protective tariffs could be removed since the infant industry was automatically assumed to have reached international competitiveness. (See Bell, Ross-Larsen and Westphal, 1984 for a critique of conventional infant industry arguments and a review of the literature.)

Beyond the infant industry debate, the concept of learning by doing described above came in time to be offered as a explanation for almost any observed improvement in productivity occurring in circumstances where there was no investment in new capital stock over a period of time - ergo the well-known concept of the "learning curve". However a by now large and coherent body of research in both the industrialised and developing countries has convincingly demonstrated that passive forms of "learning by doing" have in fact contributed very little to observed patterns of productivity growth. Indeed it has been shown to be the case that even in these studies from which the original concept of "learning by doing" is based, that quite the opposite from there being no change in existing facilities, a very wide range of technical change activities had in fact taken place - so wide that the whole of the plant's physical stock had been rebuilt from the ground up bit by bit in an incremental fashion.

In other words, observed productivity improvements in plants with "fixed" facilities arose as the result of a *conscious and explicit effort on the part of the firm and its personnel to effect incremental technical change*. There has been nothing passive at all in the process of technical change that has been observed and reported upon in the literature. Bell, 1982 cites a quote from Gold, Rosegger and Boylan's (1980) study of performance improvement in steel plants which captures this perspective:

> "*The belief cannot be justified that increasing experience can be expected to yield progressively improving results from an unchanging technological innovation*. There can be no doubt that increasing familiarity with the potentials, requirements, and limitations of an innovation can engender improvements in utilising it. However, such incremental benefits tend to diminish very rapidly. Continuing gains in performance accordingly tends to derive from modifications in the facilities, changes in operating conditions, advances in instrumentation and control, shifts in product requirements, adjustments in maintenance procedures, more effective scheduling, and similar developmental improvements. Hence, "learning curves" reflect the results of increasing familiarity with unchanged facilities and operations only during very early periods after their introduction. Thereafter they are attributable .... (far more) to progressive modifications of inputs, processes, hardware, work specifications, and operating rates - and to increasingly effective adaptions of such factors to one another. In the absence of such continuing vigorous improvement efforts, the benefits of sheer cumulative experience have been shown to be minimal indeed in a wide array of industries." (Gold, Rosegger and Boylan, 1980, p.341, original emphasis).

Many of the studies focussing on developing country experiences cited in Lecture One (and reviewed in Bell, Ross-Larsen and Westphal, 1985) confirm the findings referred to above - a large share of observed incremental technical changes and the resultant increases in productivity occur as the result of the *explicit* allocation of resources by firms to innovative activities ("vigorous, improvement efforts") designed to produce technical change. The notion that active effort on the part of the firm to generate technical changes yields measureable economic benefits therefore largely contradicts the economists' traditional assumption that productivity improvements are a costless by-product of production experience. In fact quite the opposite is true: the large bulk of accumulated evidence suggests that firms and countries are only likely to achieve consistent gains in efficiency, develop more appropriate products and processes and indeed gain greater independence from the foreign supply of technology if they explicitly set out to undertake "vigorous improvement efforts" aimed at increasing the performance efficiency of their production systems.

The crucial process of the accumulation of technological capacity

The above discussion allows us to introduce some further conceptual distinctions that lie at the heart of this set of lectures. In undertaking the "vigorous, improvement efforts" described above, firms clearly have to draw upon a pool of "resources" that allows them to effect various types of technical change. Such resources or abilities to effect technical change do not arise as if by magic. They have to be created. Indeed, policy research has revealed that those firms in both developed and developing countires that have successfully improved product and process performance via technical change also devoted explicit efforts to creating, accumulating and increasing their technological capabilities. Thus firms, and by extension economies have got to actively accumulate the human and institutional capabilities to effect technical change.

This process of the creation and accumulation of capabilities to effect technical change has now come to be known more generally in the literature as "learning". Needless to say this new definition of learning is much broader than the old concept of learning-by-doing since it encompasses all of the activities by which a firm can generate its own stock of technological knowledge. Maxwell's 1976 definition of learning comes closest to what we mean in defining learning "as the set of processes by which firms accumulate technical knowledge, knowhow and experience relevant to the planning, construction, operation, adaptation, improvement and replacement of production processes" (Maxwell, 1976, p.19-20).

There are many activities by which a firm can "learn" - these include the active involvement of staff in the process of technical change (thereby generating knowledge as well as a technical change);the carrying out of R&D; training and education to upgrade technological skills; by hiring in technical assistance (or purchasing technical knowledge) and assimilating that knowledge; by carrying out "searches" for new techniques; even by introducing systemised measurement and instrumentation of the production process.

We shall explore these learning mechanisms in greater detail in subsequent lectures but here want to emphasise two points. First, the process of learning, by itself, will not always generate technological progress; this will depend on other factors as well, such as the availability of sufficient minimal investment resources, efficient management and organisation, etc. But nevertheless, the normal reward or outcome of successful learning is technological progress. Second, learning is the result of conscious effort on the part of the firm to increase its pool of technological knowledge and resources - without a continuous expenditure of effort to expand knowledge and effect technological change, the prospects for a firm whether in a developed or developing country achieving a continuous improvement in its performance are very greatly reduced.

5. The Nature of Technological Capacity

We suggested above that firms (and economies) were generally able to effect technical change by drawing upon a pool of technological resources. Following our earlier definitions these technological resources can simply be considered to be the stock of knowledge necessary to effect technical change - i.e. what we termed technological capacity earlier on. Bell (1986), has made a useful distinction by suggesting that a firm or an economy's "technological capacity" actually consists of three elements:

(i) The first consists of knowledge necessary to specify and define new techniques. Such knowledge consists of the broadest level of knowledge about general principles that "may be applicable to a wide range of production techniques (the properties of fluids, the laws of motion, etc.) (But) as one moves to levels (of specification) that are more proximate to production, the relevant knowledge becomes more detailed and more specific to particular production systems".

Thus, with this type of knowledge the firm is able to begin with general knowledge and translate this into system-specific requirements that uniquely define either new products or production facility or specify technical change necessary to existing systems and products. Such knowledge is both likely to be in a disembodied form (i.e. textbooks, design manuals, etc.) as well as being embodied within skilled people. Hence, engineers and designers draw on their basic knowledge of how to prepare working engineering drawings in general and then combine this with more product or process-specific knowledge relating to, say, the characteristics of a particular type of petrochemical plant, to prepare the detailed specifications of a plant producing 100,000 tons of product per annum. The same process, i.e. of combining general knowledge with system-specific knowledge to produce plant-specific designs, operates in the case of individual components as well as the whole plant - in relation to machinery designs, specifying input and output specification, specifying commissioning and stand-up procedures, etc.

(ii) The second element of technological capacity is also knowledge based and therefore likely to be embodied in people. This set of skills and expertise allows the firm (or economy) to take a set of specifications and transform these into the physical reality of a new product, a new plant or a piece of equipment and/or the specified improvement to existing products, processes or equipment. Thus we can make a simple distinction between the first type of technical knowledge which is likely to be heavily based on design and engineering skills (as well as R&D skills) and the second type of technical knowledge likely to be found with capital goods firms, construction firms, plant production engineers, machine shops, etc. Such a distinction, though a useful explanatory device, is very basic and is not likely to conform entirely to reality, where the dividing lines between the two types of knowledge and the people/firms who carry out the tasks are likely to be blurred. Further we should make the point that one can also isolate another set of tasks for which technical knowledge is necessary - that of "choosing" techniques from among available alternatives. The issue of "choice" is most relevant to situations where firms are likely to be acquiring new techniques and where it needs to be able to select from among available designs, equipment models, process routes, etc. that combination that is most appropriate to its own needs. This is a situation in which many developing country firms find themselves. Unfortunately it is usually the case, as we shall see, that because they lack the skills to specify the techniques they need, they or the local economy also lacks the skills to turn those specifications into physical plant. They equally lack the skills and knowledge to make the correct "choice" of techniques -in these circumstances as we shall discuss at length, developing country firms usually turn to foreign technology suppliers to carry out all three tasks.

(iii) The third element of technological capacity specified by Bell is institutional in nature - this institutional capacity consists of both the intra-firm managerial and organisational capabilities needed to provide an environment conducive to effecting technical change; and the inter-firm relationships (i.e. between the user of a technique and the producer of a technique) within which occurs the processes of acquiring, creating and transforming this knowledge into technical change of all sorts.

> " Thus industrial technological capacity consists of a stock of (i) disembodied technical knowledge and information, (ii) human-embodied knowledge and experience, and (iii)institutional resources. Together these enable a firm or economy to produce change in the technical characteristics of the industrial

> production systems used - or at least to play an active role in that process of technical change" (Bell, 1983, p.12).

Bell makes one final distinction in his analysis that is extremely useful and one that we will use extensively in the analysis carried out in subsequent lectures. It is probably easiest if we again quote him at length on this point. In referring to technological capacity he points out that:

> " These forms of knowledge, expertise and organisation are different from, and additional to, those which constitute part of the production capacity of industry: the knowledge, skill and organisation required for ongoing operation and maintenance of existing production systems. However, the distinction is blurred at the boundary; and investment in industrial production capacity will inevitably create some resources of knowledge, skill and organisation which are required for efficient ongoing operation and able to contribute to technical change. But that area where the two kinds of resources overlap may be very small in many industries. Additional investment in knowledge and expertise, along with different kinds of institution and organisation, will be required to build up a significnt capacity for generating technical change. Consequently, investment in industrial production capacity in industry may proceed without any significant parallel investment in industrial technological capacity; and the accumulation of technological capacity in industry in developing countries will require additional investment over and beyond that needed to build up production capacity"(Bell,1986).

In the remaining 7 lectures in this series, I shall be explicity concerned with one mechanism by which firms in Third World countries can seek to invest in the creation of accumulation of technological capacity. This involves the acquisition of industrial production systems from abroad - a mechanism known commonly in the literature as technology transfer. Developing countries, as we have already noted, historically have been heavily dependent on the importation of technologies designed, developed and produced in the industrialised countries to build their industrial infrastructure. It is highly likely that they will continue to depend heavily on this mechanism as the principle source of industrial techniques for many years to come. Our concern in the remaining lectures will be to explore and understand how developing country governments and firms can exploit the process of technology transfer to accumulate not only production systems and production capacities but also the technological capacities that play such a vital role in the development process.

LECTURE THREE

TECHNOLOGY TRANSFER: AN OVERVIEW OF CONVENTIONAL CONCERNS

Introduction

Developing countries have long been dependent on foreign sources of technology. For most of these countries, this pattern of dependence began in the colonial period and was reinforced by the pursuit of import-substitution policies in the post-colonial period. Concern about the financial cost and social and political implications of this situation began to surface with the emergence of the "Dependency School" of analysis in the 1960's. Even though technology factors were not initially the centre of attention of the dependence analysts, it gradually assumed greater and greater importance in the early 1970's. During this time, the issue began to be discussed explicitly - first in a series of seminal conceptual works (by Cooper, 1974; Cooper and Sercovitch, 1971; and UNCTAD, 1972) and then empirically explored in a variety of sectoral and country case studies of which the UNCTAD Technology Transfer series (summarised in UNCTAD 1975) and Constantine Vaitsos' 1974 study on transnational corporations and technology "commercialisation" in Latin America were probably the most influential. As a result of this early research work, the problems associated with the control and regulation of international technology transfer became the principal focus of technology policy research throughout the 1970s. And although there are, as we shall see, a number of shortcomings with this body of work, the research findings were nevertheless very influential in shaping the national policies of many countries both during the 1970's and indeed into the 1980's.

The discussion I will present in lectures 4-9 will focus primarily on the potential contribution that technology transfer can make to technological development in the Third World and the policy mechanisms required to facilitate this. The approach I shall be taking to these issues differs fundamentally from the conventional concerns of the "mainstream" technology transfer literature of the 1970's, and hence there are many issues arising from this body of work that I will not be able to address in any detail. However, these "conventional" concerns do in fact provide an important context for these subsequent lectures and so in this presentation I would like to briefly review some of the principal lines of argument of the "mainstream" technology transfer literature of the 1970s.

In this lecture I will cover four topics. The first is an introduction to the basic theoretical and conceptual arguments about technology transfer since these strongly influenced the perceptions of researchers and policy makers in the 1970s and are still influential factors today. Second, I will present the essential features and problems associated with the process of technology transfer as described by the literature in the 1970s. Third, I will describe some of the policy responses adopted by countries in light of the research that was carried out. Fourth, I will present a critique of this process of research and policy response as a means of providing a link with the analysis taken up in lectures 4 to 9.

1. Some Theoretical Considerations

I would like to introduce two lines of theoretical argument here - the first dealing with the nature of markets for technology and the second with the role of technical change in a competitive economy. As with other topics of discussion presented in this set of lectures, the relevance of theory may not seem immediately obvious to our concerns with the design and implementation of technology policy. But if one looks closely, it soon becomes clear that theory is often used as a justification for the positions adopted by both North and South in the technology transfer debate. And since much of the argument is conducted along the lines laid down in conventional economics literature, consequently it is essential to be clear about the implications of theory for policy and for policy research in the field of technology transfer.

The nature of technology markets

One of the central features of the development policy currently being espoused by agencies such as the World Bank and the governments of the industrialised countries, is the need to promote development through strengthening the hand of the private sector and freeing of market forces. Such a posture implies the dismantling of many of the mechanisms that Third World governments traditionally use to intervene in and control the functioning of their national economies. This includes the elimination of tariff barriers, the removal of subsidies and the withdrawal of the state from direct participation in production via state enterprises. While this theme has long been a concern of agencies such as the IMF and the World Bank it has recently become a much more central feature of their policy advice. The importance of technology transfer from North to South is often an explicit element in this argument, along with the corresponding belief that the private sector is inherently best suited to effect an "optimal" transfer of technology - as opposed to the extensive degree of state intervention that occurs at the moment either where public enterprises are recipients or vis-a-vis the government's regulation of technology contracts and direct foreign investment. Not surprisingly the most suitable vehicle for promoting the transfer of technology is alleged to be the transnational corporation (TNC).

In the many recent pronouncements by aid and trade institutions (based in or controlled by the industrialised countries) on this issue, the stress placed on these arguments is linked to pressure on developing country governments to change their internal policies to facilitate TNC investment. Indeed, this is part of a wider trend where offers of "foreign assistance" are now often closely tied to the willingness of the government to dismantle its mechanisms for state intervention in the economy. Needless to say, the current financial crisis faced by many developing countries has considerably strengthened the hand of the IMF in this area of policy - one that is usually reserved as being the province of sovereign governments.

The theoretical rationale for this position stems directly from welfare economics and neoclassical theories of international trade.[1] The basic assumption underlying the argument being that the "free" operation of a market will establish the best price[2] for the technology being supplied to the developing country in welfare terms - i.e. by meeting the peculiar condition of Paretion Optimality that no parties to the transaction are worse off because of it, and some may even be better off. The best way to achieve this outcome is argued to be to minimise the degree of state intervention, thereby allowing market forces to operate freely. Hence this is the theoretical justification given for the opposition of developed countries and TNCs to intervention such as the international code of conduct put forward by UNCTAD, technology transfer "registries" introduced by many developing countries, and the use of laws regulating the process of direct foreign investment. All of these actions as seen as essentially distorting the operation of the market and should therefore be eliminated.

The whole of this edifice rests on a crucial theoretical assumption about the nature of technology in commodity markets. Technology (equated with information) is assumed to be freely, costlessly, and instantaneously available under conditions of perfect competition. This assumption about technology stems from its "public good" characteristics - i.e. information does not disappear when it is used and hence the social cost of its use must be zero.[3] In a strict sense, this condition does hold (though there are exceptions) and hence the price for technology (which underlies the production of typical commodities such as tables, automobiles, etc. that are the usual concern of the economics of the market) must also be zero. For if technology had a price, the conditions of Paretian Optimality simply could not be attained and there would be no theoretical basis on which to guide government policy.[4]

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1. Some of the basic references to these arguments are contained in Cooper and Hoffman 1981, on which this section is based. Here we shall only be sketching these arguments in brief detail.

2. Price being the only characteristic of technology that is discussed.

3. As opposed to a physical commodity that can be used up or appropriated thereby denying anyone else access to it.

4. The principle objective of policy in this context being the removal of obstacles to the free operation of the market.

When the argument is extended to situations where technology is the commodity being traded, these conditions break down rather badly right from the start. In the conventional analysis of technology markets, technology (despite its public good character) is assumed to also have the same characteristics as any other commodity. Hence the examination of how technology markets should operate in order to achieve an optimal outcome is conducted on the assumption that all the normal conditions for the free operation of commodity markets are in effect. And, as pointed out above, policy proposals such as those emanating from the World Bank and the IMF follow on from these assumptions.

However as Cooper and Hoffman (1981) point out, there is a whole set of serious contradictions in this position. The principal one is that it is impossible to both assume that technology can be traded in freely operating markets at a positive price and at the same time have as one of the principal conditions of the model of perfect competition being used, that technology must also be a free public good in order for there to be an "optimal" outcome in Paretian terms.

The above reasoning makes the neo-classical argument totally untenable on its own terms. Therefore any policy proposals which are based on these assumptions are also without any credence whatsoever. The reason for this is that if it is shown that conditions of Paretian Optimality cannot be achieved, then policy proposals cannot be based on the desire to achieve free markets in technology without restriction or outside intervention - hence the non-interventionist, pro-private sector arguments of the World Bank and other agencies have no theoretical basis for their policy proposals.

The reason for all of this seemingly esoteric discussion is to show that even on the terms set by mainstream economic theory, the issue of how and whether to control technology transactions (in order to achieve a fair price and good terms) is strictly a "second-best" situation. The best policy response can therefore only be judged on the characteristics of the specific situation rather than by reference to a model economy. This suggests that policy proposals cannot be based on a set of theoretical assumptions totally removed from reality[5]. Policy must instead be formulated on the basis of the nature of the expected and desired impact of the transaction on social and economic criteria, rather than on private profitability. This is a crucial theoretical point in favour of those who support intervention in technology markets. Needless to say technology policy research is necessary to provide the empirical basis for the type of policy needed in this inherently "second-best" situation.

Even without the theoretical debate, it is perfecty obvious that technology has rarely ever been treated as a "free good" in

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5.The policy proposals in this case being that there should be no state interest in the functioning of technology markets.

international technology transactions. Cooper and Hoffman (1981) show that it can in fact be appropriated and is generally sold on the basis of the conditions of exclusion imposed by that appropriation. Hence developing countries must intervene in this situation to ensure that they get the best possible deal - any notion that conditions have ever been otherwise simply ignores reality. The value of making the case in strictly theoretical terms is that it reinforces the position of the interventionists in the debate and strengthens their hand in calling for the regulation of the flow of technology to maximise social returns.

The role of technical change in competitive markets

The second strand of theory I would like to pick up centres around arguments about the motivation of foreign firms to supply technology and the influence these arguments have had on Third World efforts to regulate technology flows from abroad. The reasons why firms are willing to supply/sell their technology abroad have been extensively explored both theoretically and empirically and many arguments have been proposed ranging from the neo-classical statements by Caves and Johnson to the Marxist/dependency analyses of Baran, Frank and Hymer.

Whilst this literature offers some useful insights, in fact, I have found that the work of the German economist, Josef Schumpeter is particularly valuable as his analysis of the workings of market economies is very relevant to understanding the dynamics of the technology transfer process. As mentioned in the Lecture Two, Schumpeter believed that technical change was a major force in capitalism and largely determined the nature of competition. He explicitly argued that the appropriation of technology (rather than its free availability) was a central feature of market economies. In his analysis, the competitive economy operated in a state of constant disequilibrium - rather than the tendency towards equilibrium assumed by the neo-classicals. In Schumpeterian terms this disequilibrium is caused by the efforts of the firm to capture what are termed super-normal profits - these are profits over and above the normal profit allowed in a perfectly competitive economy. Schumpeter believed that technical change was the principal source of super-normal profits. In his view, this technical change was primarily of a cost-reducing type, with the innovation usually leading to lower per unit costs, thus allowing the innovating firm to sell its product at the same price but with higher profit margins.

Under these conditions, super-normal profit accrues to the firm until its competitors are able to copy the innovation and achieve similar cost reductions. This imitative response by competitors gradually reduces the amount of extra profit accruing to the original innovator as the price of the product falls, and the innovator is forced to reduce his prices in order to stay competitive. There is thus a tendency for the rate of profit to fall towards the normal profit rate obtaining in general equilibrium. However, in Schumpeter's model economy, this tendency is soon interrupted by the same or another firm introducing another cost-reducing innovation (in order to capture super-normal profits) and the whole process of imitative response by competitors repeats itself. It should be clear from the evidence given in Lecture One that this analysis is a reasonably close approximation of the actual function that technical change plays in market economies.

The short term advantage enjoyed by the firm (which is created for it by technical change) is termed a quasi-monopoly, referring to the temporary monopoly advantage the firm enjoys after introducing its innovation. Cooper and Hoffman (1981) argue that both in Schumpeter's world and in the real world, a firm must organise itself to protect its quasi-monopoly in order to realise its potential for super-normal profits. These do not flow automatically once the technical breakthrough is accomplished - further steps must be taken if the innovation is to reach commercial fruition. The firm gets some help in this from the patent system since taking out apatent confers an automatic monopoly. But in a competitive economy, the innovating firm can always expect that competitors will gradually erode the advantage created by any particular innovation. Hence the firm needs to continually reinforce or extend its quasi-monopoly. One way to do this, of course, is to continue to innovate in order to stay ahead of its local competitors.

Schumpeter's reasoning also suggests other ways in which firm's can extend their quasi-monopoly. One option that is of direct interest to us is for the firm to exploit its quasi-monopoly abroad in markets where (a) it does not face such stiff competition, or (b) which offer new, untapped sources of super-normal profit. In reality, firms usually consider expanding their operation abroad for very specific reasons - as a defensive response to moves by competitors, because of the location of raw materials, to exploit cheap labour, to penetrate local/regional markets, etc. Various empirical surveys have indicated that these (and other) reasons "explain" the overseas activities of TNCs. However, the value of Schumpeter's line of reasoning is that is places the firm's control over its technology (or innovation) as being the crucial determinant of its ability to generate super-normal profit from overseas operations - whether these involve the sale of products, the licensing of technology or direct investment. Hence whatever form these operations may take, the firm's principal underlying objective must always be to maintain control over its source of quasi-monopoly.

These arguments about the crucial importance of control provide the basic starting point for my introduction of the principal themes in the conventional technology transfer literature.

2. Mainstream Views on Technology Transfer

Development theorists in the immediate post-war decades tended to omit any explicit consideration of the role of technology in their analyses of development strategies for the Third World. There was of course much discussion and emphasis placed on the need for countries to pursue industrialisation strategies as the quickest route to development. Implicit in these arguments was the assumption that developing countries would acquire their technology from the industrialised countries. In so doing, it was thought that the South could take advantage of the sophisticated technological resources of the North, transplant the fruits of their R&D and bypass all of the costs and problems associated with developing technologies from scratch. Direct foreign investment was thought to be the best vehicle for ensuring that this process occurred to the benefit of everybody involved.

However, in the late 1960s and early 1970s a set of empirically based studies identified the process of technology transfer as an issue and problem area in its own right, separate from the more general concerns of industrialisation strategy. Resting on an analytical framework strongly influenced by the Dependency School, these studies identified a number of central problems which have dominated both subsequent research and policy formulation throughout the 1970s.

Early work by Vaitsos (1974) and the Transfer of Technology Division of UNCTAD (summarised in UNCTAD (1975)) tended to link the problems of technology transfer with direct investment by transnational corporations in local markets via the establishment of 100% wholly owned subsidiaries. In many sectors in a number of countries, TNC subsidiaries were found to control a large share of the local market - often as high as 100% in some sectors such as motor vehicles and pharmaceuticals. It was argued that TNCs were therefore responsible for the majority of technology flowing between North and South.

Related to this focus on TNCs as the main source of technology was the belief of these analysts that the involvement of TNCs as suppliers of technology to their subsidiaries in developing countries or to independent local firms via licensing agreements resulted in both the recipient firm and the local economy incurring unnecessarily high financial and social costs to acquire what was often highly inappropriate technology. In a number of these studies, contracts and licensing agreements between foreign suppliers and Third World recipient firms were reviewed which showed a very high percentage of restrictive clauses, excessive direct charges for the technology via payments for patents, royalties and license fees, as well as a good deal of evidence of transfer pricing (these issues will be discussed in detail in Lecture Seven).

TNCs were seen to be able to impose such unfavourable terms and conditions largely because of their strong bargaining power vis-a-vis the weaker and less sophisticated host firm/country. Moreover, a number of these studies showed that these problems were most extreme where there was an equity relationship between supplier and recipient. Thus the greatest degree of costs became associated with the domestic presence of wholly-owned subsidiaries of foreign TNCs. The evidence on transfer pricing initially amassed by Vaitsos on the pharmaceutical sector in Colombia was particularly important in establishing a link between wholly owned subsidiaries and high financial costs incurred by exploitative technology transfer arrangements. Vaitsos (and others such as UNCTAD, 1972) argued strongly that the degree of foreign equity participation was directly related to the ability of the foreign firm to control the activities of its local partner. As this was obviously the position enjoyed by TNCs via their wholly owned subsidiaries, this form of acquiring foreign technology became extremely suspect. It was believed that by exercising full control over its subsidiary, the TNC was therefore able to repatriate the maximum level of monopoly profits. Thus the involvement of TNCs as the dominant suppliers of technology via wholly owned subsidiaries was assumed to be the cause of the observed high foreign exchange costs that the economy was incurring through acquiring technology from abroad.

3. Policy Responses by Third World Countries

Both the researchers and policy makers, particularly in Latin America, drew a number of immediate and direct policy implications from the results of these studies. The first, and perhaps most important of these was that in order to reduce the costs of technology transfer it was necessary to reduce the level of involvement of TNCs in technology flows. One means of doing this was to impose reductions in the level of equity in domestic firms that foreign firms were allowed to own - particularly in sectors which were deemed crucial to the economy. Hence, legislation was passed in a number of countries which stipulated that foreign equity shares were not allowed to go above 49 percent - on the assumption that the 51 percent which remained under national ownership would ensure local control of the firm, local control of the transfer process and hence lower costs. Secondly and related, this concern with the deleterious effects of TNC involvement led to a search for less costly forms of transfer. This led researchers in particular to articulate other ways by which technology could be transferred that did not involve the excessive costs associated with wholly owned subsidiaries. This concept of different "mechanisms" for technology transfer was developed by authors such as Cooper and Sercovitch (1970) who assessed the nature of the various modes of transfer used by foreign suppliers such as the wholly owned subsidiary joint venture arrangements (with majority local ownership), various types of licensing agreements, management contracts and other technical service agreements as well as more straightforward direct purchases of equipment from machinery suppliers. The characteristics of these different mechanisms are all extensively discussed in the literature and we do not intend to repeat this discussion here.

However, I would point out that this literature emphasises that one of the principal characteristics distinguishing these different mechanisms was the degree of equity control or ownership of the recipient by the foreign supplier. The objective assumption underlying this distinction being that mechanisms which involved less foreign ownership afforded better opportunities to acquire technology at a reasonable cost, i.e. there was assumed to be an inverse relationship between the costs of transfer and the degree of foreign ownership. Thus the acquisition of technology via joint ventures was preferred over wholly owned subsidiaries; license agreements over joint ventures; direct purchases of equipment from machinery suppliers over joint ventures and so on. Firms and governments were urged to seek relationships with foreign suppliers that were ideally of an "arms length" nature - where no equity relationship was involved at all such as license agreements, technical service agreements or machinery purchase contracts with firms. The assumption implicit in this argument was that suppliers willing to agree to non-equity relationships would be smaller in size and with less bargaining power than TNCs, and therefore would agree to less costly contractual terms.

These arguments were very influential with Third World policy makers and were at least partially responsible for the introduction of government policies that were designed to shift the mode of technology acquisition away from the use of wholly owned subsidiaries during the 1970s in many Latin American countries. Thus the work in particular of Constantine Vaitsos was directly responsible in Latin America for the technology transfer policies enacted by the Andean Pact countries in the mid 1970's (see Junta 1976 for a discussion). In turn the actions of Latin American governments in this sphere persuaded other governments in the Third World, particularly those in Africa, to institute similar policies.

A third policy implication of this early research was related to the existence of so-called restrictive clauses in technology transfer contracts. The existence of these clauses, such as those relating to tied inputs or restrictions on exports was linked to excess financial costs that had to be borne by the recipient. In some cases these costs were incurred as direct charges, i.e. by contractually requiring a recipient to purchase inputs or raw materials only from the technology suppliers, said suppliers could charge a "monopoly" price on inputs that could normally be acquired more cheaply on the international markets. In other cases, indirect costs were involved - by restricting a recipient from exporting a product produced under license, the supplier was in effect depriving the recipient of potential revenue.

Hence it was argued that some institutional means should be found to limit the level of direct costs (i.e. by imposing a ceiling on royalty and patents payments) as well as to eliminate any restrictive clauses from contracts which might incur indirect costs. The most common means of doing this was to set up a government body which regulated and vetted all technology transfer contracts to ensure that the offending clauses were removed before the contracts were approved. Many countries introduced such legislation (see UNCTAD 1980 for a review). These issues are discussed further in Lecture Seven.

4. Symptoms or Causes? A Critical View

As noted there can be little question that the research mentioned above and the policy conclusions drawn from the results were very influential in persuading governments to introduce legislation and policies which were reasonably successful in reducing some of the excesses found in the studies.

In so far as much of the literature had focused on the high rates of repatriated profits associated with specific types of technology transfer agreement, the resultant policies equally concentrated on trying to eliminate the specific problems highlighted in the literature. Consequently, as noted, in certain countries, the degree of permissable foreign equity participation in a local firm was reduced to below 50 percent in order to ensure local control, while at the same time policies were enacted to eliminate certain restrictive clauses from technology contracts.

Similar initiatives were inaugurated by UNCTAD at the international level with its efforts to reach agreement on an international "code of conduct" for technology transfer. These efforts to establish a code of conduct consumed a tremendous amount of time, but in the end proved unsuccessful because of the refusal of developed country governments and TNCs to accept either the arguments for a code or the evidence on which the case was based[6]. However, the attempts by individual governments to control the short-run costs of technology transfer were more successful. For example, UNCTAD (1980) presents a fairly comprehensive review of the experience of legislation in this area. The report shows, for instance, in relating the efforts of Colombia to the Licensing Regulation Committee to vet technology transfer contracts that between 1967-1971, the Committee evaluated some 395 contracts. It was able to renegotiate most of them and this led to a reduction in royalty payments of 40 percent, or the equivalent of US$8 million - an amount then equal to the whole of Colombia's direct payments for technology. Other countries were equally successful in imposing legislated reductions in royalty rates or in forcing the removal of unnecessarily restrictive clauses from technology contracts (see also Junta, 1976 and Chudnovsky, 1981).

These early efforts to control the cost and terms on which technology was obtained were certainly necessary and represent significant steps in the right direction. The loss of revenue due to monopoly pricing and the imposition of restrictive clauses by technology suppliers was then and remains now a very sizeable drain on resources for Third World countries - and yet many countries, particularly the poorer ones, have not even now put in place even the most basic regulatory mechanisms. Clearly they need to pursue the establishment of such policies to eliminate the most blatant excesses.However, there are grounds for questioning whether efforts to deal with the short-run financial problems caused by technology transfer are in themselves sufficient to deal with the underlying causes of the problems described above. And if the criticisms we offer below are correct, it suggests the need for a fundamental reassessment of the nature of the policy intervention called for by the mainstream literature.

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[6] Despite this failure it is arguable that the code of conduct debate served to considerably heighten the awareness of Third World governments to the importance of technology transfer.

There are two issues in this regard that I would like to highlight. Firstly, the empirical evidence on which much of the conventional wisdom (and the many policy measures that were put in place) was based was actually quite narrow. There was in the mid-late 1970's an inordinate amount of research carried out which concentrated on only three Latin American countries:- Mexico, Argentina and Brazil: as well as on India. The experience of African countries was hardly examined at all before the late 1970s with the exception of UNCTAD's study of pre-revolutionary Ethiopia and Kaplinsky's (1976) study of Zambia. Other regions of the Third World such as the Caribbean, Central America, the Middle East and South East Asia were also neglected - though the Caribbean Technology Policy Studies Project funded by the IDRC of Canada, greatly expanded our understanding of what was occurring in the West Indies in the late 1970s.

The same reservation applies to the sectors on which detailed empirical evidence was generated. Once again only very few were studied extensively, such as pharmaceuticals and chemicals, while other important sectors were virtually ignored. Of course by the late 1970's the scope of research carried out on the short-run problems of technology transfer had broadened somewhat - for instance Odle and Arthur (1984) studied the contents of technology transfer contracts in the West Indies; Langdon (1981) explored the role of TNCs in Kenya and so on. However the geographical and, in particular, the sectoral scope of this research still remains so narrow that it suggests, at least to me, that this research had an impact and influence on policy and thinking that went far beyond what was actually justified by the range of countries, sectors and firms investigated.

Another aspect of the narrow base of these empirical studies was their excessive concentration on the role of TNCs in the transfer process. There is little question that TNCs do play an important role in international technology markets - but the concentration of research efforts on TNCs has meant that much less attention has been paid to the problem and possibilities of technology transactions involving smaller firms, machinery suppliers and so on. The discussion in Cooper and Maxwell, (1975) shows for instance that the extensive involvement of these non-TNC firms in technology transfer presents an equally formidable set of research and policy problems as those associated with TNCs, since they are just as prone to charge monopoly rents, impose restrictive conditions and supply inappropriate technology as are the TNCs.

Moreover there is other evidence which in effect challenges other aspects of conventional views of technology transfer. Reuber (1973) for instance showed that in numerous cases it was Third World firms which actually sought the equity participation of TNCs as a means of ensuring successful technology transfer - this finding is in sharp contrast to the view that suggests that TNCs are always the aggressor or initiator of technology transfer. Other research for instance by Contractor (1982) and Balasubramanyam (1973) show that the willingness of TNCs to effectively transfer technology is in fact directly related to the degree of equity participation.

We are not emphasising these gaps in coverage or contradictions in evidence because of any "academic" concerns with comprehensiveness. Nor do we question the value and validity of many of these early studies. However, conditions governing the costs and benefits of technology transfer do vary greatly across countries and sectors and the policies that are relevant for one country will not be directly transferable to a different country on the other side of the world at a totally different level of development. Nevertheless these early studies did have a pervasive influence on policy in a number of countries where similar research had not been carried out and as a result, these policies tended to have unintentional deleterious effects. For instance the stringent foreign investment regulations imposed by many African government in the 1970s did little to increase the social gains accruing from TNCs already established, and virtually totally eliminated new flows of technology and foreign capital of all kinds into these countries. In India, restrictions imposed on royalty payments and contractual clauses allowed Indian firms to reduce the short-run costs of the technology transfer but also significantly decreased the willingness of foreign firms to undertake any real efforts to effectively transfer technology.

Policy obviously cannot be formulated in a vacuum and the experiences of other countries can serve as useful "signposts" in where to focus action. However the design of detailed policies cannot draw in any substantive sense on work done in vastly different countries, yet as the above discussion suggests, this happened and continues to happen to a large extent in many developing countries in this field.

5. Dynamic Forms of Quasi-Monopoly

The geographical and sectoral bias of early technology transfer research is only one of the problems we wish to highlight. A second and much more fundamental shortcoming of the conventional approach to research and policy lies in its emphasis on short-run issues and on the need to reduce the high costs and eliminate the restrictive clauses that are allegedly character istic of technology transfer. These problems are of two different kinds.

First, the emphasis on short-run financial problems associated with technology transfer has virtually ignored problems associated with the accumulation of technological capacity[7] - a problem which inevitably has a much longer time horizon and one where policy objectives often conflict with the shorter term concerns about high costs and restrictive practices. We shall be taking up the relationship between technology transfer and capability accumulation in much greater detail in Lectures 4-9 and so will leave further discussion of these issues until then. Secondly, as noted, past policy and research has tended to overemphasise the importance of eliminating specific forms of transactions and contracts - e.g. reduction in foreign equity control below 50 percent, the removal of particular types of restrictive clause, or limiting the level of royalty payments - with the assumption being that these moves will thereby reduce the costs of the transfer and increase benefits accruing to the economy.

This, however, is a far too static interpretation of the nature of technology markets and the motives of the technology suppliers who enter these markets; and in particular it ignores the dynamic forms of quasi-monopoly which characterise technology transactions between developed and developing countries.

We can explain this point by making reference to the Schumpeterian model discussed in Section I, which suggests that when a firm chooses to extend its activities abroad, its ultimate objective is to maximise the flow of super-normal profits. Possession of a quasi-monopoly provides the market power that these firms seek to exploit and hence they will tend to organise themselves (or their activities) in order first to protect their assets and second to ensure the required level of return. In this situation, the firm has available to it a very wide variety of institutional and organisational forms of control that it can employ to achieve these objectives. And rather than being wedded to any specific form of arrangement, the firm is concerned primarily to use whatever combination of transfer mechanisms and contractual forms that are necessary to maintain the required flow of super-normal profits.

Hence, the use of a particular organisational mode of transfer such as a wholly owned subsidiary or a specific form of contract is a reflection of the supplier firm's response to the factors affecting the market and conditions in the host country at that time, rather than being the only form of transaction in which that firm will engage. As conditions change in the market, say because of government intervention to limit the size of royalty payments and the allowed share of foreign equity control, it is logical and obvious that the supplier will change the forms of transaction it utilises as well in order to sustain its rate of profit.

Consequently, if the supplier is using a combination of royalty payments and transfer pricing on exports to remit surplus, the introduction of legislation which limits royalties or closes one transfer accounting loophole will simply cause the supplier, not to forego those profits, but to use other conduits such as tax provisions or overcharging on inputs to achieve the same level of profit - the total amount stays the same, only the channel of transmission changes. As Cooper and Hoffman (1981) argue, in such a fluid situation unless comprehensive control can be exercised, legislation of the type imposed by many Third World countries which restricts only one aspect of supplier activity is likely to have only a limited effect.

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[7] Even though these issues were identified as early as 1972 as being of particular importance (see UNCTAD, 1972).

Similarly, moves to limit foreign ownership to below 50 percent on the grounds that this also reduces the ability of foreign firms to control local operations have been shown to be pretty ineffectual in this regard. The essence of the supplier's ability to control the operation of local firms lies not in its degree of ownership but in a wide variety of other areas linked to its particular technology-based quasi-monopoly or set of market assets. Kaplinsky (1976) and Cooper and Hoffman (1981) both demonstrate cases where suppliers have been able to retain fundamental control over local firms through means of a joint venture or licensing contracts or technical service agreement. The resulting costs to the economy are similar to those which would have been incurred had a wholly owned subsidiary been involved. Once again the flexible way in which control can be exercised suggests that the wisdom of placing so much policy emphasis on limiting foreign ownership seems questionable unless accompanied by other types of intervention.

Another way in which firms may change and adapt the forms of control they employ lies in their ability to shift location of the quasi-monopoly to aspects of production over which they have a higher degree of control, e.g. moving from controlling local production to controlling international distribution of exports. For instance, in the early 1970s there was a fairly common view that those mineral exporting developing countries which have been able to reduce the degree of foreign ownership in the mineral sectors by nationalisation for instance, have been able to shift the distribution of surplus in their favour. However, it has been shown subsequently that the mineral multinationals, although at first forced to accept lower profit rates, have now been able to restructure their international markets so as to shift the location of profits to the distributional channels which they still dominate[8].

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[8] The same is true of TNCs operating in the export crop sector. For instance sugar processing firms such as Tate and Lyle were hit by a wave of nationalisations in Africa in the 1970's. However they were often asked to stay on as local managers via management contracts. This was a highly desirable state of affairs for them as it meant not only did they retain control over international distribution of the product, but received an outright (and exorbitant) fee for managing the plantations without having to shoulder any of the risk!

By emphasising the flexibility of the forms of control open to technology suppliers I do not wish to suggest that there is not a preference among suppliers for a particular form of organisation in developing countries. Clearly, the wholly owned subsidiary provides the supplier with the most unrestricted means of operation since there are no legal boundaries between parent and subsidiary. However, given particular circumstances, the supplier is just as likely to opt for more limited equity while retaining virtually the same degree of control and hence profit repatriation. The range of transfer mechanisms employed, the type of contracts used, and the profit remission channels developed can all be combined in a variety of ways. This is particularly borne out if we look at the relevant business literature of the 1970s which discusses the most appropriate forms of transfer, and the methods of international organisation best suited to facilitate achieving supplier objectives - whether as parent or licensor. A common feature of this literature was that it urged flexibility in the design of the specific mechanisms.
One frequently finds lists of transfer mechanisms given in this literature that differs markedly from the much more limited set of mechanisms that were proposed by academics in the 1970's as alternative modes of transfer (see, for example, Cooper and Sercovitch, 1971). Not only are there many more variations, there is also much less concern than in the academic literature about the different characteristics of the mechanisms particularly vis-a-vis the lower degree of equity involvement that is possible with joint ventures and licence agreements. In effect, while academics and policy makers were worrying about classifying different mechanisms according to various criteria in order to avoid equity control, suppliers were (and are) willing to adopt whatever mechanism and whatever form of payment was (and is) necessary to achieve their objectives. This point is underlined by another bit of advice that management consultancies frequently give to firms who are about to become involved in 50/50 joint venture arrangements in developing countries. This advice is often quite explicit about how US firms, for instance, can retain control in a joint venture situation including Third World partners and for instance frequently suggest four ways that this can be done:

(i) Issue two kinds of stock - voting and non-voting that will divide the profits evenly but give a majority vote to US side;

(ii) Through the specifications of bylaws or agreements of association which ensure that the US side will have a majority of directors;

(iii) Split ownership 49/49 with 2 percent in hand of third party friendly to US firm;

(iv) Arrange a 40/60 split, but allow US partner to have a management contract.

Quite clearly, as the above makes obvious, the central concern from the supplier's perspective is about retaining control over its quasi-monopoly.Conceptually the point we are making is quite straightforward. In practice it is likely to prove a good deal harder to implement policies which take into account the flexible forms of control open to the supplier. Countries must be able to exercise control over the entire range of profit remission channels open to firms in order to ensure that total outflows are kept at acceptable levels. Partial control over some avenues is insufficient to ensure this.

Ideally the host government or firm should know the precise nature of the supplying firm's quasi-monopoly - whether it be a particular innovation, patent rights, marketing rights, etc. - in order to determine its optimum bargaining strategy.By identifying the assets which the supplier is trying to control and exploit, the host country or recipient can structure its own approach to negotiations and policy and not be misled by static concerns with the short-run costs of the transfer. However, as the following discussion on packaging shows, this is likely to be very difficult as the quasi-monopoly created by control over technology can provide firms with considerable market power.

6. The Concept of Packaging

The concept of packaging is perhaps one of the most useful (and durable) of the ideas which emerged out of technology policy research in the 1970s. It has a great deal of relevance as an analytical tool and even now can provide an important basis for policy formulation. The concept and supporting empirical information is extensively discussed in Cooper and Maxwell (1975), Vaitsos (1974) and Cooper and Hoffman (1981), so we will simply summarise the main elements of these analyses.

There are a few basic analytical components to the packaging discussion. The first of these is that projects involving the transfer of technology will actually be composed of a number of elements. If we think for instance about what is involved in the erection of a new steel or petrochemical plant, the literature suggests that the following activities or elements of technological knowledge are required to get the project underway:

market analyses
feasibility studies
detailed design and engineering studies
machinery selection and fabrication
plant selection and fabrication
process know-how/product know-how
construction and installation
project management
operation and maintenance activities
spare parts and material inputs supply
quality control

Even though there are a number of elements in the above list, it is still very aggregated. Each category involves a whole range of specialised skills which need to be applied and organised during the transfer process. Nevertheless the list shows the range of technical/technology inputs which need to be present.

Depending on the degree of technological capabilities possessed by the recipient firm, it may need to rely on outside sources for some or all of these elements. Where North-North transfers are involved, recipient firms frequently need only the most specialised elements of process know-how from outside suppliers as they are able to provide or organise all the other peripheral elements from their own internal technological resources.

However, where North-South transfers are involved, the situation is vastly different. Recipient firms frequently lack the technological capabilities and to provide even the most basic of these elements; and these are usually equally unavailable from local sources. Hence conditions in both local and international markets tend to create a situation where the recipient firm is forced to rely on one or a few firms to supply all of the elements listed above. As a result, the recipient firm has little or no control over how the transfer process is organised.

Concern over the effects of packaging largely centre around two different sets of implication for the recipient firm and the host economy. The first relates to the cost of the transaction and rests again on the concept of the supplier's control over technology as a source of its quasi-monopoly. A firm which possesses a quasi-monopoly over one of the elements listed above, may be able to establish control over other elements and offer them as a package to the host organisation. It can do this in a variety of ways - if it controls a crucial element of technical knowledge - e.g. process know-how, the firm can simply refuse to supply that element unless the host country or recipient firm agrees to acquire the whole range of services on offer. Alternatively, the supplier may "engineer" each of the elements so that they only function as a system and cannot be assembled independently. This can be most clearly visualised in the case of a production line composed of a number of individual machines which although they can be obtained as separate pieces of equipment, can also be adapted by the supplier to "fit" together as an integrated production process available only from that supplier.

Packaging can also occur where a whole series of elements are involved. It is frequently the case that a supplier, originally specialising in the provision of process know-how for petrochemical plants, also chooses to undertake the design process, construction and commissioning of the plant as well as supplying the process technology itself. It may also be in the firm's interest to maintain control over the subsequent operation of the plant or use of the technology so that it can supply intermediate and raw materials, ensure the plant's efficient operation and the quality of final product and most importantly receive payment for all of these services.

Indeed the great advantage of packaging to the technology supplier is that it allows the firm to establish a quasi-monopoly over elements of technical knowledge which may in fact be widely available individually from other suppliers. Hence the firm is able to force the prospective buyer to accept these non-monopolised elements so that it can acquire the monopolised element of technical knowledge that it really wants.

Consequently, the supplier will be able to charge a price for the package which includes a degree of super-normal profit on each element, which if available separately would be much cheaper. And as we have already argued, the technology owner will be able to establish a number of channels through which it can extract super-normal profits in addition to the straight "price" of the package, e.g. royalties, transfer pricing[9], fees for management services, patents and trademarks, etc.

As with the concept of control, packaging is also a highly flexible concept that has been used to describe many different situations involving totally different types of supplier. For instance, the establishment of a wholly owned subsidiary is clearly the highest degree of packaging that involves the joint supply by one firm of all elements of technical knowledge as well as the capital necessary to establish and operate to the enterprise. However, as we have noted, it is equally the case that engineering firms can organise and provide all the elements on a turnkey basis with no equity participation at all - but still generate a substantial flow of monopoly profits. Similarly, two or three suppliers may combine to provide different components of a package in which they are all linked together. Foreign consultant responsible for preparing feasibility studies often recommend a package of foreign suppliers/techniques.

As in the above example, it is equally possible that each of the elements can themselves be packaged in varying degrees. Cooper and Maxwell (1975) discuss the case of machinery suppliers and show that contrary to expectation, the packaging of direct machinery purchases, long reckoned to be the simplest form of transaction with little scope for monopoly pricing, in fact affords suppliers considerable opportunity to do just that[10].

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9. The concepts and empirical evidence relating to transfer pricing are discussed extensively in the literature. See for instance Lall (1973).

10. Given such a wide range of possible combinations, Cooper and Hoffman (1981) suggest a simple two-way categorisation of packaged transfers which they relate to the types of supplier involved, the elements of technical knowledge in the package and the different cost categories associated with these. Readers should refer to the paper for further discussion of "process" and "project" packaged transfers.

Although the above points about packaging focus primarily on the suppliers' ability to charge monopoly rents, they have been superceded by other concerns which provide an important linkage with the central theme of Lectures 4-9. Cooper and Maxwell (1975) argue that in addition to the problem of monopoly rents, packaging can have even more serious negative impacts on local learning opportunities. The reasoning is obvious - if all the elements of technical knowledge are supplied in package form from abroad, then local firms are not going to be given the opportunity to participate in the project - thus denying them valuable experience in supplying technological inputs. If local firms are denied these opportunities over a sufficiently long time period, such skills as do exist are going to be seriously underutilised and will become marginalised from the production system. It is now widely accepted that this is a much more fundamental problem than issues of high short-run cost. Indeed it is quite likely that policies designed to reduce short-run costs may create even greater problems in the longer run for the accumulation of technological capabilities. Because of both of these effects, the concept of "unpackaging" is a very attractive one for policy makers and for firms since it can result in financial savings and in increased local learning opportunities. Simply stated "unpackaging" implies a conscious effort on the part of the recipient to source individual items of technology from different suppliers - foreign and local. However it is not, as some analysts have implied, an easy strategy to follow - particularly for recipients who are operating without the benefit of government support. The degree to which a firm is able to unpackage its technology purchases will also depend on the degree of its own technological capabilities. Identifying and negotiating with alternative suppliers, setting specifications, and putting the components together all require a certain degree of technical skills that increase as the system gets more complex. Once again, it is a costly time consuming business to generate these skills and the recipient needs to be persuaded that it is in his interests as well as those of the state to develop them and as we have seen the operation of the local market does not favour the local firm pursuing such a strategy.

Unfortunately much of the discussion in this area has not recognised the complexities of unpackaging even though the idea has been around for some time. Nevertheless, the concept is one of the most crucial underlying the approach taken in the Lectures Four to Nine and I shall return to it in detail then.

For much of this discussion I have presented the standard set of arguments and perspectives regarding the problems of technology transfer faced by developing countries as enshrined in the literature, and in government policies in a number of countries. I do believe that most of the central concerns in this body of literature are an accurate reflection of very real problems. TNCs do dominate the supply of technology; a very great deal of monopoly rent is extracted in payment for technology which is not well suited to local conditions; and the operation of local and international markets tends to reinforce the problems faced by technologically weak recipient firms. Moreover, the picture that has been painted - where developing countries are seen to struggle to avoid foreign control and reduce the level of exploitation is one that is intellectually appealing. However, I also believe that there are many problems with this sort of perception of the nature of North-South technology transfer.

The reasons for my concerns are that this approach is essentially negative in its articulation. It is, as I have tried to show, rather easy to build up a very tightly argued case that there is very little that Third World countries, particularly the poorer countries, can do to break out of the current conditions governing their acquisition of technology from abroad. This argument seems to afford those countries very little room for manoeuvre - except to adopt largely defensive policies such as those aimed at reducing short-run costs or eliminating foreign ownership. Such arguments also place the blame for many of the problems that stem from the transfer process largely on external forces, such as TNCs.

In Lectures Four to Nine, I shall be adopting a very different perspective as regards the problems and potentials associated with technology transfer. For one thing, despite the formidable array of externally imposed obstacles that do exist, I believe that many of the problems faced by developing countries in this area are avoidable and can be ameliorated by the action of governments and firms. I prefer to view technology transfer not as a costly burden which must be minimised wherever possible, but as the best opportunity open to many developing countries to contribute to the development of their indigenous technological capabilities. There is a need, however, for careful policy research to provide the foundation for policies desgned to exploit the transfer process - rather than allowing the Third World to be exploited by it.

LECTURE FOUR

AN APPROACH TO THE ANALYSIS OF THE PROCESS OF INTERNATIONAL TECHNOLOGY TRANSFER

Introduction

In Lectures One and Two, I stressed that the experience of both developed and developing countries has shown that a country's ability to effect technical change is a central determinant of the rate of economic growth and therefore the rate at which national and per capita income rises. I showed that this capacity for change can have a number of identifiable and in some cases measurable private and social benefits such as: extracting more output from fixed facilities, the more efficient use of scarce resources, greater linkages with local input suppliers and improved international competiveness.

I gave numerous examples of how the process of technical change that gives rise to these technological externalities was heavily dependent on the deployment of the country's stock of technological resources or capacities; and how likewise the failure to accumulate and use these resources resulted in very real costs to firms and to the economy in terms of the inefficient use of existing facilities; declining productivity over time; a high and continuing degree of dependence on imported inputs and of techniques; and a lack of local linkages and therefore limited integration of the industrial sector.

Given that these capacities are crucial, it seems obvious that steps need to be taken to augment a country's pool of technological assets. There are of course many mechanisms by which such capacities can be created or added to. Historically, and for many reasons, a great deal of attention has focussed on the role of investments in R & D and education as a means of improving society's stock of technical knowledge and its capabilities to use this knowledge. There can be little doubt that these are important mechanisms. However, developing countries can also increase their stock of technical resources through other means. Over the course of the next 6 lectures, I will be exploring one of these mechanisms - the process of investing in the creation of new industrial production facilities based on the acquisition of technological resources from abroad. By effectively exploiting the process of international technology transfer, it is possible for developing countries to substantially augment their own stock of technological resources. From this perspective, the whole of the transfer process should be viewed not just as a means of acquiring productive capacity at the lowest price but as a learning process which can have major positive long term effects upon the development of the country's technological capacity and ultimately upon its whole pattern of development and economic growth.

By and large most Third World enterprises and their governments have failed to exploit the full learning potential of technology transfer even though this has long been a stated "objective" in many policy documents. The argument is frequently offered that this is due to a variety of externally imposed constraints which limit the ability of Third World enterprises to gain substantial technological benefits from technology transfer. The direct policy implications of these arguments are that changes need to take place in the external environment before substantial improvement is possible on the part of local firms.

Now, it is the case that such external constraints can certainly pose major obstacles to effective technology transfer and the development of technological capacity. However we do not accept the related view that Third World enterprises must remain totally passive participants in a technology transfer process that takes place under exploitative arrangements. There is, in fact, a great deal of room for manoeuvre open to those enterprises who acquire technology from abroad, to acquire it on terms which contribute to the long term development of their technological capacity.

However in order for this to occur, recipient firms must first recognise the importance of increasing their technological capacity, and they must then be be prepared to invest the effort, time and resources required to do this through technology transfer. In Lecture Two when discussing the sources of technical change, I emphasised that a principle characteristic of the learning process observed in many developed and developing country firms was that they were prepared to take deliberate steps to organise themselves to effect technical change - and in doing so to invest in the development of new/additional technological capacity. What I will try to argue throughout the next set of lectures is that this is equally true of learning via the transfer process, and like the learning process discussed earlier, recipient firms and host governments must take deliberate steps to maximise the learning potential of the transfer process. As the experience of many developing countries demonstrates, unless this is done, the development of technological capacity will not happen automatically (no matter what economic theory tells us!). Instead, Third World countries have frequently found that they need to continually re-import the same pieces of equipment or rely on foreign problem solving expertise over long periods of time - even when one of their main policy objectives has been to reduce such dependence.

It will be one of our primary contentions that developing countries must acquire both technological capacity and productive capacity from technology transfer - otherwise the sort of dependence mentioned above will inevitably continue and probably even increase over time. Unfortunately even though this reasoning is plausible and is backed up by historical experience, it is by no means obvious how this should be done nor what precise steps need to be taken. More importantly it is highly likely that such efforts will be costly and time consuming. It is not difficult to forsee that private sector firms are likely to be relucant to undertake any activities which do not show promise of an early and reasonable financial return - indeed the same can probably be said of many public sector enterprises as well.

Quite apart from external constraints mentioned above, there are a variety of other factors which impinge upon the local firm and make it unwilling to incur additional costs in departing from its traditional modes of technology importation to acquire benefits which are ill-defined and may anyway be difficult to capture in the short run. This underlies the point that Third World enterprises frequently do not appreciate or understand the importance of building up technological capabilities beyond those required to maintain production which yields a reasonable profit. This reticence may be reinforced by a pattern of demand or market structure that does not reward investment in "learning" - whether this be associated with in-firm research to effect minor technical change, sub-contracting to local, but untried, technology suppliers or negotiating with foreign suppliers to include extensive training as part of the technology package.

The existence of these problems, of course, provides an excellent rationale for government intervention in the transfer process to promote local capability development. Given the extensive role of Third World government in the process of technology acquisition both as direct recipients via public enterprises and through their legislative, fiscal and administrative apparatus, they obviously possess the most effective means of intervention[1] and it is to government policy makers in this area that much of our concerns about the need for policy research is addressed. But unfortunately much government policy as regards technology transfer is not directed at persuading firms to develop an independent technological capability.

Rather than encouraging firms to undertake the risks and additional costs involved in such efforts, policy measures often discourage such behaviour - through the creation of enforced monopolies behind protective tariffs which allow firms to be uncompetitive and unconcerned about improving efficiency; by tax provisions which encourage the import of capital goods which could be supplied locally; or by central bank concerns about financial rather than social profitability which forces local firms to opt for "reliable" foreign contractors.

We do not believe that the reticence of local firms nor the inadequacy of present government policy towards the use of technology transfer as a learning vehicle is a given and unchangeable fact of life in the Third World. In the next five lectures I will present a framework for the analysis and discussion of the main policy and research issues associated with maximising the learning potential of the transfer process and the contribution that it can make to the accumulation of indigenous technological capacity.

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1. Assuming, of course, as we do, that developing country participation in international technology markets is a "second-best" situation.

The approach taken will differ considerably from that adopted by what in Lecture Three we termed the mainstream technology transfer literature, and there are probably a few points worth mentioning by way of introduction to the topic and to our approach. Firstly, I will be presenting my ideas first in terms of a very simple "model" of the transfer process and its different stages; and following this up with the use of empirical material to back up the arguments. Secondly, I intend to discuss this model in a good deal of detail, adopting a micro level approach more akin to that of a project manager than an economist. Thirdly, while much of the literature is concerned with what might be called supply constraints on effective technology transfer, we shall concentrate much more on the activities of Third World recipient enterprises, the host government, and local technology suppliers. The reason for this is that these entities are much more amenable to intervention than the suppliers of technology whose position and objectives, as unhelpful as they may be to Third World interests, must be taken largely as given.

Finally we shall be presenting a necessarily over-simplified pucture of a complex process. This notion of the complexity of technology transfer actually has several different aspects which we try to encompass in our analysis. At one level, many different types of recipient enterprise are involved in acquiring technology from foreign suppliers. However I shall make only a simple distinction between public sector firms and private sector firms. There can of course be important differences between these in terms of size, sector and the nature of the market conditions under which they operate; but though these are important in research and policy terms we do not need to address them in conceptual terms. In addition many different types of supplier may be involved in transfer projects - TNCs, state enterprises, owners of process know-how, small machinery firms, etc. And, as mentioned in Lecture Three, there are a variety of institutional transfer mechanisms which can relate supplier and recipient in varying types of equity relationship - wholly owned subsidiary, licensing agreements, technical service contracts, direct machinery supply, etc.

Obviously there are far too may permutations of these different characteristics to be discussed individually. I shall therefore be trying to present a general analytical framework which is flexible enough to be applied to most situations. However, my comments are perhaps most directly concerned with large projects involving relatively substantial new investments in a new capacity where the public sector is involved either as direct recipient or indirectly through its fiscal and administrative apparatus.

The reasons for this are straightforward and obvious. Large public sector projects frequently account for a substantial share of total technology acquisition in the industrial sector in LDCs. The percentage tends to be higher in smaller, poorer countries where the formal industrial sector is still poorly developed. In many African countries, for instance, public sector enterprises alone account for over 80% of all new investment involving the acquisition of foreign technology. Because of their lumpy nature relative to the rest of the economy large investment projects involving the establishment of a new plant or facilities such as large engineering works, can have a disproportionate impact on skill creation and technological infrastructure as well as substantial financial implications for the economy as a whole. Hence concentrating my analysis on this area should encompass much of the problems and potential associated with technology transfer in poorer developing countries.

1. Resource Flows in Technology Transfer

The distinction made in Lecture Two between production capacities and technological capacities is crucial in our approach to analysing the transfer process. Following the arguments of Bell (1982) I want to suggest that the transfer process esssentially involves flows of different types of technological resources over international boundaries. The first type are those resources which are used to establish new production facilities, i.e. new textile plant, or a new galvanising line in a corrugated steel factory. Such resources expand the production capacity of the importing firms and the host economy and include, inter-alia, physical hardware (i.e. plant and equipment) as well as operating manuals, construction specifications, etc and of course managerial and technical operating skills to keep the plant operating.

The second resource flow incorporates those technological resources which in effect contribute to the expansion of the technological capacity of the importing firms and host economy; and which consists of the technical knowledge, skills and experience that underlies the capacity of a firm and an economy to undertake technical change activities. These resources are of different types and as Bell (1982) indicates may in turn be split into two categories. "The first would include technical knowledge about the particular type of production facility itself - the underlying technological principles and technical information that has been transformed during the process of investment and embodied in the particular facility by that process. The second would include elements of the technical knowledge, skill and experience required to carry out that transformation process - to carry out economic feasibility studies, to execute different kinds of engineering tasks, to transform engineering specifications into capital equipment, to assemble elements of equipment into integrated facilities, to define operational procedures and implement their application, and to manage the overall process of acquiring, transforming and integrating the elements of new units of production capacity."[2]

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[2] Bell, 1986, further develops this categorisation by separating out Type A flows into two categories - the first involving a flow of capital goods and engineering services; and the second flow consisting of operational know-how.

These two flows are illustrated in Figure 1 with Type A flows being the resources which are incorporated into the new production facility, and Type B flows being those resources which add to technological capacity. Clearly those resources which are relocated in Type A differ substantially from those in Type B. This may seem obvious but it is important to bear in mind that not only do the resources differ, very often they are likely to be found in different people, and groups within the same firm, or indeed in different types of firms entirely.

The activities related to production are distinct from those related to tecnical change, even though as is obvious they may draw on the same basic pools of knowledge. Even more importantly, while flow A by definition has to actually take place in order to get the facility established and operating, there is, of course, no guarantee that flow B will take place. From our research perspective, what is important is trying to ascertain the size of flow B relative to flow A; what is important from the policy point of view is trying to devise policies which ensure that Type B flows takes place to the greatest extent possible. This obviously does not mean ignoring Type A flows, nor does it mean that we need assume Type B flows will automatically take place. The point is simply that while some of Type A flows always occur, Type B flows occur much less frequently, yet are arguably much more important to the long- term well being of the recipient firm and the host economy.

Figure 2 illustrates a second set of features of our "model" of technology transfer that are important to bear in mind. This is the time dimension. Most firms (and more broadly an economy) typically engage in a series of discrete investment projects involving technology transfer that will take place over a number of years. Such projects may involve the successive duplication of existing production facilities (i.e. building a number of textile plants using the same type of production system), the internal expansion of an established facility (through adding a new line), or the building of an entirely new facility to produce a new product. Conceptually these details do not matter at this stage - the important point that the diagram tries to show is that the technological "outputs" of investment project TT1 should be treated as a domestic technological input which can be fed into TT2, thereby substituting for imported flows of these resources. This means of course that the pattern of demand for foreign technological resources will or should change over time as the domestic pool of resources expand. In some cases there will be an outright substitution of local for foreign; while in others we would expect the type of foreign resources required to shift towards more specialised inputs.

Hence our concern with maximising Type B flows during technology transfer has an important time dimension; since the process of accumulating technological capacity through technology transfer necessarily takes place over long periods of time, policy towards this activity needs to focus on (i) increasing Type B flows in individual projects and (ii) maximising the flow of Type B resources over successive projects, and on (iii) effectively managing the way in which domestic and foreign technological resources are drawn upon in the process of establishing new production facilities in the light of a hopefully growing pool of domestic resources and an increasingly more sophisticated demand for foreign resources. It is important to bear in mind that what we are talking about above is a "model" view of what we think should happen. As we will discuss at great length below and in subsequent lectures, our model is unfortunately by no means an accurate picture of what actually does happen in most North-South technology transfer projects.

2. Supplier and Recipient Response

If we take account of this point, it should be clear that the model of technology transfer presented above has some important implications for the way in which both suppliers and recipients would be expected to behave. For both sides, their responses and their strategies would of necessity be quite different from what generally occurs out in the field.

I can illustrate this strategy/response issue with reference to Figure 3. Basically this shows that a technology supplier possesses three types of resources at its disposal:

In Ring C are what might be called its "core" technology - that set of technologically based assets that are the key to its market strength. These may be process know-how, secret formulae, engineering expertise, patented products, product design capabilities, even marketing and management skills. The supplier must protect these assets very closely - for to lose them means losing market advantage. Consequently, firms are unlikely to be willing to relinquish control over or provide access to these assets except in extreme circumstances. In other words, these resources are almost never transferred from the supplier to the recipient.

A second type of resources are those found in the outside ring, Ring A. These are resources that are always transferred - i.e. equipment, operating procedures etc, and these roughly equate to our notion of production resources or capacities.

It is the resources in the middle ring, Ring B, that we are most interested in. These resources fall largely into the category of what we call technological resources, and like those in Ring C, these resources are rarely willingly transferred by suppliers. However, we would argue that their availability for transfer is at least open to negotiation, (and present extensive evidence to support this argument in the next lecture). What we are suggesting in principal is that a key aim of a technology acquisition strategy designed to increase the size of flow of Type B resources during the transfer process is to get the technology supplier to provide more of the resources contained in the middle band - in effect to move the boundaries of what is normally transferred by the suppliers inward as close to the technological core as is possible.

Now, how far it is possible to push the suppliers to make these resources available to the recipient depends on a variety of factors, such as the precise nature of the technology involved; the existing technological level of the recipient; the availability of such resources from elsewhere; the respective bargaining strength of the two sides, and so on. However, there is an important point to make here about the implications of the above discussion for the "conventional wisdom" in the technology transfer field. The point is this. As I argued in Lecture Three, concern with short-run costs in the 1970s led policy makers to pursue two sets of objectives with regard to the regulation of technology flows - the first was to eliminate the monopoly profit enjoyed by the supplier by legislating cost reduction, and the second was to avoid a monopoly situation by "unpackaging" the technology and by sourcing different components from different suppliers.

The logic of my argument suggests that recipient firms should adopt precisely the _opposite_ strategy. If a recipient firm actively seeks to gain access to more of the middle band of technological resources or indeed to the core resources of the supplier firms then it is hardly likely that the supplier is going to allow such access unless it is adequately compensated. This suggests that the recipient may have to pay a good deal more for this type of technological resources than if it were content with just acquiring the contents of the outer ring. Such a proposal is of course anathema to those who argue that technology should be supplied to the Third World at a low cost because it is a "free good". Yet paying premium prices for gaining access is precisely the strategy that was adopted by the Japanese and increasingly is being pursued by a select group of NICs, who increasingly are recognising its long term value to their technological development.

Moreover, where conventional wisdom suggests that the recipient should attempt to "unpackage" technology transfer projects and sources from different firms, the obviously integrated nature of the three rings of supplier resources suggest in fact that where recipients wish to acquire access to Type B resources _they may be well advised to deal with a single supplier instead of sourcing from a variety of suppliers!_

3. The Phases of the Technology Transfer Process

In order to facilitate an analytical discussion of precisely how firms and governments are meant to go about gaining access to the dynamic technological resources of the supplier, I believe it is useful to conceive of the transfer process involved in a single investment project) as consisting of three phases, each of which involves a set of technological and managerial activities.

Figure 4 is one way of depicting this three phase process. The first phase is what I have termed the pre-investment phase. This consists of a seemingly straightforward set of activities which generate the information necessary for decisions to be taken on whether or not to go ahead with the proposed project; what type of production system and product will be involved; who will supply the technology; on what terms; and in what manner. This is the phase in which a variety of "paper-based" activities need to be carried out - pre-feasibility and feasibility studies, marketing studies, etc., with the final actions in Phase I being the actual negotiation with the suppliers over the terms of the transfer, responsibility of the different parties and so on.

Phase II is what we call the investment phase of the transfer process. During this phase, as the figure shows, a large variety of actions occur, beginning with setting out the precise engineering specifications of the production system to be built and the way it is to operate, through the fabrication of plant and equipment, the construction and installation of the facility. The final actions in Phase II are those involved with the commissioning of the plant.

Phase III is the post-investment phase. Compared to Phases I and II which are of relatively short duration, this phase refers to the full operating life of the plant, a period which can or rather should involve attempts to improve operating efficiency and often to achieve capacity expansion either through new investment or through what might be thought of as "stretching" the capacity of the plant. The important point to note here about this phase is that whereas in relation to Phases I and II, when the main concern is with maximising the size of Type B resource flows, in Phase III the main concern should be with applying those capacities to the task of improving plant operation and raising efficiency.

Now obviously, one of the main objectives of policy and firm strategy is to ensure that the production facility established via technology transfer will operate continuously and to capacity throughout the whole of its operating life, with levels of efficiency continually rising. As should be clear by now, the firm's ability to fulfill these objectives during the operational phase of the plant will be directly related to its ability to draw on its stock of technological capacities.

As we have argued and will show in subsequent lectures, effective management of the pre-investment and investment phases of the project will allow the recipient firm to add to its stock of technological resources. And this in turn will directly contribute to its performance during the post-investment, operational phase of the project. Thus during the rest of these lectures, I shall be concentrating my attention on analysing and understanding the nature of the processes occurring within the pre-investment and investment phases (Phases I and II) of the transfer process.

4. Government Intervention in the Decision Making Stream

We have so far defined the three phases of the transfer process primarily in terms of technological activities. In fact, throughout the rest of the lectures we shall be emphasising the importance not only of technological activities but of decision-making as well. The flow of technological activities which occurs during the different phases is necessarily accompanied by a stream of decision-making activities that conceptually can be seen to run in parallel with the technological activities, and which in fact control the way in which the transfer process, and all of the technological activities that go on within it, are carried out. Figure 5 attempts to depict the way in which these two streams of activity - technological and what we have called techno-managerial tasks - interact between each other and over different phases.

Implicit in our view of the decision-making, or techno-managerial, stream of activities is that it occurs at two levels. The first level obviously takes place within the firm since it is actually physically engaged in the investment project and is going to be responsible for taking most of the immediate decisions regarding the project. However, particularly in developing countries, there is another level of decision making/control that exerts considerable influence on the actions of the recipient and indeed on the shape, structure and orientation of the transfer project itself. These decisions are taken within government institutions or agencies responsible for different dimensions of industrial policy and development projects such as the Ministry of Industry and Planning, the National Development Bank, Science and Technology Agencies, Ministry of Commerce and Finance, etc.

The decisions of some of these institutions are likely to have a direct effect on the project and the actions of the recipient firm, particularly if it is a public sector firm. For instance the Development Bank that has to approve finance, the Contracts Registry that has to vet all contracts with foreign firms, and where relevant, the Ministry within which responsibility for the public sector recipient resides. Other of these agencies are likely to have a more indirect, but nonetheless potentially important impact on the projects. The Ministry of Planning which sets output targets for public sector projects, the Ministry of Trade with its general policies on the import of capital goods, etc. As should be clear, the government can affect investment projects and decisions taken by the recipient firm itself both directly and indirectly through its policies. Because of this, one of the central themes of my subsequent lectures will in fact be the importance of the decision-making stream in influencing the outcome and the distribution of costs and benefits arising from technology transfer.

In addition to these concerns, the lectures will attempt to address four key issues. First in relation to my argument about the importance of increasing the flow of Type B technological resources, I shall be examining the evidence of whether or not this has actually happened at the firm level in North-South technology transfers in the past. Second, I shall be trying to understand how such firm-level efforts were organised, what were the mechanisms that were used, what were the effect of these, and what has been their long-term impact on firm performance. Third, I shall explore also the nature of government intervention and government policies that were involved in supporting or stimulating these efforts (or alternatively stopping them from occurring). And finally I will along the way attempt to draw out the implications for policy and particularly for policy research of the line of argument I shall be pursuing.

LECTURE FIVE

PREPARATION AND SEARCH: THE ROLE OF DECISION MAKING IN THE PRE-INVESTMENT PHASE

Introduction

The next two lectures are concerned with the first stage of the transfer process: the pre-investment phase. In this lecture I shall present a conceptual overview of the pre-investment phase. My objective is to set out an analytical framework that allows us to focus on the relationship between the preinvestment phase and the process of capacity accumulation. In the next lecture I shall introduce a good deal of empirical information to examine past performance in the pre-investment phase in light of the framework and questions raised in this lecture.

My view of the scope of the pre-investment phase is that it covers the period running from the point at which the need for an industrial project requiring foreign technology is identified by a local firm or the host government, through the process during which negotiations are undertaken with prospective suppliers, to the start of the investment phase of the project.

Though many activities take place during this phase, these can be separated into two categories - those preparatory activities that lead up to the final selection of the primary foreign technology supplier(s); and the bargaining process during which the recipient firms and host governments sit down with the prospective supplier to negotiate the precise terms and conditions under which the investment phase of the project will be carried out.

1. Some brief comments on the role of bargaining

Much of the technology transfer literature and a good many policy initiatives at the national and international level have been concerned with issues related to bargaining. This emphasis stems partly from historical factors - for instance early work by UNCTAD, and others stressed the importance of bargaining in determining the international distributions of costs and benefits from technology transfer. This perception was reinforced by the publicity given to major disputes involving Third World governments and transnational corporations that occurred in the late 1960s and early 1970s when there was a spate of attempts at nationalisation that involved extensive negotiations between the state and TNC's (see Phillips, 1976; Kaplinsky, 1976; and Desai,1972). Moreover, economic analysis tended to concentrate on the bargaining process as the central determinant of the price of the transaction, a factor which was also a major concern of developing countries at that time, who believed they were being charged monopoly prices by technology suppliers.

I believe that the significance attached to the bargaining process as a determinant of the distribution of costs and benefits arising from a transfer project is misplaced and overemphasied. Policies designed to strengthen the bargaining power of public sector enterprises may be equally misdirected since they focus, in my opinion, on the symptoms (weak bargaining capabilities) rather than the causes of the problem. From this perspective, I would argue that many of the most important decisions affecting the outcome of the project accumulation - are taken not during the negotiation process but well before it. The outcome of the negotiations may well be an agreement stipulating the precise terms and conditions governing the transaction and these terms may be unfair (or not) to the recipient under the specific circumstances. But all of this largely takes place after the recipient should have specified its technological requirements and identified the supplier best suited to meet its objectives. Frequently, of course, this does not happen - the recipient is then left with no option but to negotiate with a supplier who may offer the wrong technology on highly restrictive terms, which the recipient firm is forced to accept because of its weak bargaining capabilities.

Thus my argument strongly suggests that recipient firms and host governments must shoulder a large share of the historical blame for entering into transfer agreements which could have a negative effect on both the firm and the economy - yet it is precisely these unfavourable transfer agreements that are usually offered as evidence by those who believe that the developing countries are exploited by foreign suppliers of technology. In contrast to this I am suggesting it is (or should be) the recipient's responsibility for ensuring that the foreign partner in the transaction is the one that is best suited to meet its technological requirements. If this does not happen, the TNC or foreign engineering firms can hardly be justifiably criticised for exploiting the situation since their whole raison d'etre is to maximise the benefits and minimise the costs of any transaction. This is simply good business sense on their part.

In presenting this argument I am of course, overstretching the point about recipient 'culpability' in creating conditions inimical to their own best interests. I certainly do not wish to imply that the difficulties that Third World firms encounter in acquiring technology from abroad are solely of their own making. There are obviously many unavoidable externally imposed constraints on their freedom of action and on their ability to make the optimal choice of suppliers. These frequently exist because of the firm's historical links with the supplier, because of the constraints imposed by government policy or by tied aid or for other politically based reasons. However, even taking these difficulties into account, I believe that the onus for remedial action lies clearly with the recipient and host government rather than on the supplier. I would go further to suggest that the possibilities for undertaking effective intervention are well within the existing managerial and technical capabilities of many enterprises and as I shall argue, many of the most critical steps necessary to ensure effective transfer should be taken during the preparatory phase which I discuss below.

2. Technological Actions and Decision Making in the Pre-Investment Phase: The Key to Effective Transfer

In general terms, I view the preparatory phase as consisting of a succession of stages that begin at a general level where the broad outlines of the project are first defined - and then move through a 'narrowing down' process whereby the parameters of the project defining the precise technology required and the suppliers to be involved are specified in increasingly detailed terms. During the preparatory phase two types of activity are undertaken. The first are essentially technological in nature and involve the carrying out of various types of economic and technical studies and analyses - in effect these are the initial stages of the transformation process described in Lecture Four. These studies are normally seen as providing the information basis on which the second set of activities depend - that of taking decisions on the economic viability of the project, on the specification of the techniques to be used, and on the identity of the suppliers with whom final negotiations are to be undertaken.

To facilitate an analysis of these two streams of activity, I want to suggest that three stages of transformation/ decision making occur during the pre-investment phase. The first, project identification, is when the broad outlines of the proposed project (i.e. location of the facility, product type, scale of output, etc) are defined. The second can be termed process definition, when the detailed technical parameters of the project are established and when provision and cost estimates are calculated. The third stage primarily involves supplier selection when the final choice of technique and supplier are made.

With this three stage category in mind we can now proceed to look in more detail at the nature of the technology transformation and decision making activities that occur at each stage.

Technological Activities in the Pre-Investment Phase

Three types of technological tasks are normally undertaken during the pre-investment phase, each of which can be equated to the three stages described above. These are normally done in the form of studies prepared according to the criteria, guidelines and specifications set out by the recipient firm or responsible government agency.

In the project definition stage, the studies carried out are usually collectively referred to as pre-feasibility studies.

These are preliminary project overviews which seek to establish the general viability/need for the project by indicating the nature of demand, the financial and other benefits arising from the project, suggesting possible location sites, indicating the general level of finance required, etc. These studies also normally highlight any specific problems (technical, economic or social) which require further more detailed analysis. Generally the level of technical detail required in a pre-feasibility study is not high, though broad technical alternatives are often presented and assessed. Nevertheless, these are quite important in defining the broad parameters of the project and in defining the nature of the returns hoped for.

Such studies are often produced as part of the national planning process in order to generate a 'shelf' of public sector projects which broadly meet national objectives and can be brought into being as resources permit. In this case, pre-feasibility studies may be prepared by teams in the relevant ministry who are somewhat removed from the problems facing the public enterprise ultimately responsible for implementing the project. Where the enterprise itself is responsible for pre-feasibility, this is normally done 'in-house' but may be done by a team with little or no management responsibility.

During the process definition stage, feasibility studies are carried out. These are more detailed studies of the proposed project which provide the basis on which a decision will be taken on whether or not to go ahead with the project. As such they document the social, economic and technical parameters of the project in considerable detail. Fairly detailed analyses will also be done of the factors likely to affect the success of the project, e.g. the scale of the market, expected trends in input and output prices, the specific nature of demand, characteristics and expected performance of competitive products, the effects of existing (and possible changes in) government legislation, the scale of the investment required and the expected rate of return. Cost-benefit analyses may be carried out in addition to a financial analysis to assess employment impacts, foreign exchange costs, welfare impacts on specific social groups, etc.

The technical component of the feasibility study is usually fairly high and sufficient technical information will be collected on performance, input specification and availability, infrastructural requirements, recipient capabilities, etc. to allow a comparative costing of different technological options. Frequently such studies carry very specific recommendations regarding the most suitable technique and those suppliers who should be invited to tender.

The level of technical detail and hence expertise required to provide such detail is quite high. It is quite common for foreign consultants to be brought in to carry out the feasibility study - a fact of life in many developing countries which is both unavoidable and as we shall see, a source of many subsequent problems.

Finally during the supplier selection stage, engineering specifications and tender invitations can be prepared. Once the decision to go ahead with the project is taken, much more detailed specifications of the technology, plant and machinery are prepared; along with instructions regarding desired modes of implementation, production schedules, etc. These heavily engineering biased documents provide the basis on which suppliers submit their tender bids for the parts of the project in which they wish to be involved - and such bids subsequently provide the starting point for final negotiations with the recipient.

The technical demands on the recipient at this stage are quite high both to prepare the specifications as well as to evaluate the bids. As a result, foreign consultants are also involved at this stage - and are often but not always the same enterprises who participated in earlier stages.

The sorts of studies and documents described above should be prepared for every investment project of any scale in developing countries whether in the private or public sector. Unfortunately it is sometimes the case that these studies are not carried out at all, or else they are done superficially. This in itself is a major problem since it severely inhibits the ability of the executing agency to take decisions which meet stated objectives. There are many reasons for this failure, some of which we will discuss below. However the main point we wish to make here is that even when the full range of preparatory studies are executed, they rarely address the central issue with which we are concerned - that of finding the most effective mechanism for organising the transfer process to contribute to the technological resources of the recipient economy.

To further clarify this point, consider the range of information provided by pre-feasibility and feasibility studies and supplier selection studies. Were the issue of capability accumulation a central concern of the recipient firms/host government, then it is easy to imagine that such studies (in addition to the normal range of issues addressed) could (a) identify the range of know-how, services and machinery needed for the project and seek to identify which of these were available from local supplier, (b) assess which of the alternative production systems could maximise the use of such local inputs, and (c) identify those foreign suppliers willing to provide the training necessary to either upgrade local suppliers or transfer the technological know how to recipient personnel. Unfortunately, as we will demonstrate below and in the next lecture, such considerations are rarely taken account of by those carrying out preparatory studies. Again the reasons for this are complex. Among the most important is the fact that those individuals/agencies responsible for taking decisions about the content of preparatory studies frequently fail to recognise the importance of using technology transfer to contribute to indigenous technological capacities.

Technological Capabilities in the Pre-investment Stage

Implicit in the above discussion is the point that a certain degree of technical expertise must be present before actions can be undertaken or decisions made. This has a number of obvious implications that should be noted. Firstly, different categories of skill are going to be required depending on the type of function to be performed. Hence there will be a need for the skills of different types of engineer, environmental experts, economists, technicians, etc. which will need to be brought to bear upon the decision making process and the related activities discussed above. (See Kamenetsky (1979) on this point).

Secondly, at the same time, differing degrees of skill/expertise will be required, e.g. as there is a need to take increasingly complex decisions or to prepare the more detailed sort of engineering specification, the quality and technique specifity of the skills available at that point must also increase.

Thirdly, in one sense this suggests that a higher degree (and more wide ranging mix) of skills will need to be involved at later stages in the pre-investment phase than during the earlier stages. This is obviously true in so far as the technical skills needed to prepare detailed engineering specifications will be of a higher level than those needed to prepare the pre-feasibility study. However, the point does not hold where the decision making process is involved. Those responsible for framing the initial terms of reference to begin the project identification process must have a clear idea of the nature and relative weight of the different objectives that the project is supposed to meet and have a sufficient breadth of knowledge and experience to be able to ensure that the parameters defining the scope of pre-investment phase activities encompass and/or emphasise those objectives. To a certain extent, the existence of higher quality decision making skills can compensate for the lack of the skilled manpower needed to carry out feasibility studies, etc. Even if foreign consultants are required to perform the tasks themselves, a rigorous and competent management team or decision making cadre can ensure the quality of the product - whoever produces it.

The lack of such skills can be very costly if the public sector enterprise is unable to properly assess the proposals put to it. A particularly graphic example of this occurred recently in an East African country, where the government was asked to consider $35 million project involving the establishment of an ethanol plant. Responsibility for vetting the feasibility of the proposal was given to a university team which was asked in particular to evaulate the technological component of the project. The team gave a satisfactory rating to the proposal and the project went ahead. After many delays the plant was fianally constructed at a total cost of $100 million. However the plant was never successfully commissioned. Not only were the design specifications faulty, but the technological route chosen by the prime contractor had never been properly tested. None of these faults were picked up by the University evaluation carried out at the feasibility stage. Moreover, the government also did not realise that the foreign contractor had never built an ethanol plant before and were simply using the opportunity of building the plant to gain valuable design experience! All of these problems stemmed directly from the fact that the evaluation team lacked the technical expertise necessary to carry out a crucial part of the pre-investment activities.

Decision Making in the Pre-investment Phase

The technological activities described above are usually accompanied by a stream of decision making/managerial tasks as we have noted. These are particularly important - though this importance is rarely recognised. Three levels of decision making can be defined. The first relates to the specifications of the terms of reference of the studies to be undertaken. These define the questions to be answered by the study, the specific types of information to be collected, even the mode of information generation to be pursued.

A second layer of decisions determines who/which enterprise is going to carry out the specified activities. Considerable leeway is open to the decision maker to specify the experience, origin, qualifications etc. of the executing agency. As should be obvious, some firms are going to be more qualified to do the tasks requested than others. Consequently this suggests that these choices can be crucial to ultimate success of the project - particularly since it is frequently the case that the foreign firms who are asked to carry out preparatory studies often have a strong say in determining who the final supplier will be.

The third layer of decision making centres around the evaluation of the studies submitted and the further specification of action on the basis of the recommendations and information they contain. Running through all three stages of the pre-investment phase there will be a series of go no-go decisions which must be taken based on an assessment of whether the information provided by the various studies fulfilled the terms of reference and is adequate to allow any decision at all to be taken on the choices being presented. The decisions need not, of course, be limited to simply confirming the recommendations of the report - these can be rejected and new studies demanded.

From the perspective of our particular concerns with the role of technology transfer as a vehicle for capability accumulation, the most important point that emerges from the above discussion is the central role of decision making in ensuring that this objective is met. There are clearly many points during the pre-investment phase when decision makers can introduce criteria designed to maximise Type B flows during the transfer process. There are two points I would make about this however. The first is obvious and relates to argument made in the introduction - if such criteria are not introduced until formal negotiations with the primary supplier take place, then almost certainly these will have little ultimate effect on the size of Type B flows that occur during the investment phase. Second, I would argue that the most critical point in the pre-investment phase where these criteria have to be introduced in fact comes right at the very beginning - literally when the project is conceived. If using the project to make the maximum feasible contribution to local technological resources is not one of the main objectives right from the outset, then any decisions taken later on to exploit these possibilities may have only a marginally positive effect. I take up this point in further detail in the next section. By way of a summary of the discussion so far, Table I sets out the three stages of the pre-investment phase with their related technological and decision making activities.

TABLE I: STRUCTURE OF THE PRE-INVESTMENT PHASE

Stage	Type of Activity
Project Definition	Pre-feasibility Studies
Process Specification	Feasibility Studies
Supplier Selection	Engineering Specifications and Tender Invitations

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3. The Cumulative Process of Decision Making in the Pre-investment Phase

It is, of course, common in the development economics literature to see such decision making processes analysed in a 'choice of techniques' framework. Such a framework suggests that technology buyers are presented with a set of clearly defined technical alternatives which they choose between on a straightforward comparative cost basis. There are obviously cases where it is possible to make choice of technology decisions in this way - such as when selecting standard items of 'off-the-shelf' equipment. However, in larger scale investment projects involving more complex processes or packaged technologies, the decision making process is not nearly as clear cut as the choice of techniques arguments implies. In fact, it is probably more accurate to depict it as an evolutionary process, whereby the decisions taken at each stage place boundaries around the scope of actions that can be pursued in subsequent stages as the set of options is narrowed down, the technique specifications become more concrete and precise, and the bids of competing suppliers are evaluated.

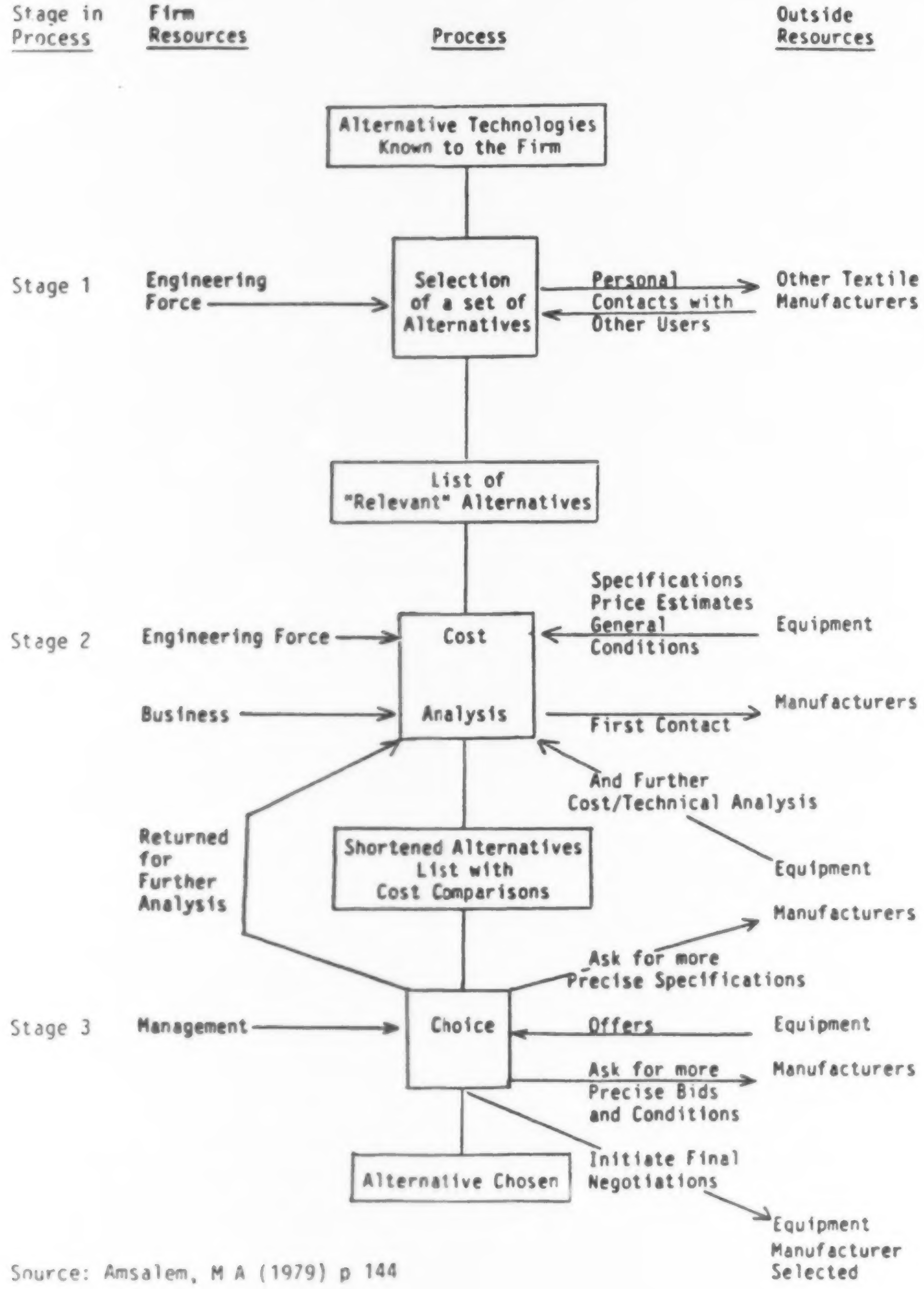
One implication of this is that as the process moves forward it becomes increasingly more difficult to introduce new criteria or widen the options considered at any particular stage. This is because a complex set of linkages can build up (in terms of technical, economic and even political factors) which tend to channel the process in a particular direction - with an all too often predictably negative outcome. Take, for example, the classic objective of 'unpackaging' whereby the aim is to organise the transfer process to allow local firms to provide input to the project. Unless the criteria that define this as a key factor in the process of supplier and technique selection are present from the beginning, then it is unlikely that a bargaining strategy which includes this as an objective will be very successful - the technology may not allow it and the supplier may simply refuse to consider it as an option.

As should be clear from my earlier comments, the direction or manner in which this evolutionary process moves forward is essentially determined by the interaction of the criteria and the information sources that are brought to bear on the decision making function at the earliest stages of project preparation. In the same way that decisions are taken on the basis of whether raw materials should be imported or sourced locally, decisions can equally be taken on the extent to which local engineers should be allowed to participate in or carry out design work, or if the equipment supply is to be sourced from firms willing to carry out training of design engineers. If, as is commonly done, the cost/benefit streams are broken down to calculate the impact of the project on the shadow price of labour and other traditional measures such an analysis can equally include some estimate of the external benefits arising from the training provided for local R&D personnel, or design engineers or capital goods firms.

As mentioned earlier, such criteria are rarely employed, particularly in the early phases of project definition. In the subsequent process definition stage, this omission is often repeated and these concerns do not enter into the terms of reference. The evolutionary character of this process - and its subsequent effects on opportunities for learning and local sourcing are highlighted by Amsalem (1978), who examined the decision making process involved in the establishment of public sector textile plants in a number of Third World countries. It should be noted that Amsalem was centrally concerned with understanding why so many Third World investment projects relied on systems supplied by firms in the industrialised countries when in many cases, fully competitive alternatives were available from firms based in the Third World. Though this focus does not directly address our concern, Amsalem's analysis is nevertheless particularly illuminating.

Table II presents Amsalem's schematic outline of the 'choice' process which he divides into three stages that roughly correspond to our own categorisation of the preparatory phase: Stage I involves selection of alternative techniques; Stage II involves what he calls the 'cost analysis' of these techniques; Stage III involves the selection of the supplier. Amsalem's discussion indicates that although the decision makers at the final stage can seek to extend the information available to them about alternative suppliers; the choices they actually make are totally constrained by the information made available to them from the prior (second) stage in the process. This second stage involves studies that generate cost comparisons and related information about the merits of the various system options and suppliers. Amsalem identified a number of common weaknesses in the managerial analyses of the competing system made at this stage and implies that 'better' choices in Stage III might have been made if there was a more sophisticated pool of skills and expertise available to carry out the Stage II studies. However, whatever the limitations of the information generated at that second stage, its effectiveness in turn depended heavily on the nature of the first stage:

TABLE II: THE CHOICE OF TECHNOLOGY DECISION PROCESS IN THE TEXTILE INDUSTRY


Stage in Process
Firm Resources
Process
Outside Resources
Alternative Technologies Known to the Firm
Stage 1
Engineering Force
Selection of a set of Alternatives
Personal Contacts with Other Users
Other Textile Manufacturers
List of "Relevant" Alternatives
Stage 2
Engineering Force
Business
Cost Analysis
Specifications Price Estimates General Conditions
Equipment
First Contact
Manufacturers
And Further Cost/Technical Analysis
Equipment
Returned for Further Analysis
Shortened Alternatives List with Cost Comparisons
Manufacturers
Ask for more Precise Specifications
Stage 3
Management
Choice
Offers
Equipment
Ask for more Precise Bids and Conditions
Manufacturers
Alternative Chosen
Initiate Final Negotiations
Equipment Manufacturer Selected

Source: Amsalem, M A (1979) p 144

> This stage in the decision process, and the way in which it is performed,...seems to condition *much of the outcome of the whole process as far as technology choice is concerned*. (p. 145)

This first stage involved the assembly by engineers (far down in the decision making chain) of information about the various systems that were to be considered. Amsalem points out that *very rarely would the range of options be widened at any later stage*. Moreover he shows that the engineers collecting information on alternative production systems rarely undertook an exhaustive review of all the alternatives available. The list of alternatives proposed was normally drawn largely from the engineers' personal experience and involved "their judgement of what would be viable technological alternatives for the production facility considered" (p. 145). As a result:

> in most of the cases studied, the list of proposals contained no more than two or three technological alternatives and each of them was generally represented by different models *proposed by the equipment manufacturers*. (p. 146)

In other words, the engineers given responsibility for carrying out technological studies at Stage I (i.e. the project definition stage in our terms) rarely undertook any systematic search process; yet the *information about alternative technologies which 'happened' to be available to the engineers at the start of that process* had a major influence on the outcome at its end. Moreover, there appeared to be considerable bias in the nature of the information base provided by the engineers. In a significant number of cases, Amsalem concluded that equipment from developing countries was the optimal, but nevertheless un-chosen, alternative. The reason why they were not selected was because they were not even *considered* by the engineers.

> ...none of the production facilities we studied, with the exception of the Indian venture in Indonesia, used equipment manufactured in a developing country from local designs. Furthermore, for none of the firms was such equipment included in the list of alternatives made by the engineers.... The result of this lack of information was that the technologies chosen were often the most labour intensive available from developed countries' equipment manufacturers, although still suboptimal in comparison with technologies available from other developing countries. (p. 159)

Amsalem concludes that enhanced information flow to the engineers working on Stage I tasks might have improved the nature of final decisions (i.e. resulted in the selection of the equipment from developing countries). However, he goes on to point out that simply providing 'more' information to the engineers may not have been adequate since much will depend on the *credibility* of the information to the engineers involved. This is particularly so since (i) their direct experience of the equipment in use seemed to be a major influence on whether they considered it or not, and (ii) they were seldom under any managerial pressure with respect to their choices and judgements in listing relevant options:

> ...in none of the firms we visited were the criteria on which to make these judgements, or the guidelines to be used, set by management.... When questioned, the engineers themselves could not offer a set of criteria on which their decisions to exclude or include a technology or manufacturer were made. In these discussions 'experience with the manufacturer' and 'renown of the manufacturer' were often mentioned as well as 'well proven design' and 'widely used technology'. (p. 145)

In contrast, when asked about the reasons for not including equipment from developing suppliers, the engineers responsible for drafting the initial lists generally replied that:

> ...they had heard about textile equipment produced by developing country firms but did not know who they were and what were the types of equipment they were offering. They generally added that, although they had no information, they had heard or had the impression that this equipment was not of good quality nor was it efficient. (p. 159)

Thus in the cases studied by Amsalem the ultimate decision taken in Stage III to select equipment from developed countries rather than developing country suppliers were esentially pre-determined right at the beginning of Stage I by a combination of the engineers' xenophobia and lack of information, and the failure of decision makers responsible for setting the terms of reference at Stage I activities and for evaluating those studies to indicate to the engineers the types of alternatives they wished to be considered.

I believe this brief analysis of Amsalem's work captures the essence of the evolutionary nature of the decision making process we have been describing. In particular, it highlights the importance of the active management of the preparatory phase whereby efforts are made by (the presumably more experienced) managers responsible for final decisions to intervene directly and early on in the preparatory phase to ensure that information is collected and analysed according to the criteria desired by management - rather than being left to the more junior people with less experience.

Unfortunately, the problem may also be the reverse of the above - engineers involved with more practical day-to-day operations are often very concerned about the constraints imposed by the lack of skills or the marginalisation of their own role in production and transfer; management on the other hand may be more preoccupied with risk minimisation, or with dealing with the pressures from the ministry for better performance, or be enamoured of the need for the best and most modern foreign technology, etc. and hardly be concerned at all with undertaking the much more time consuming, strenuous and painstaking sort of intervention called for here.

As we noted, Amsalem was interested primarily in whether the user firms considered Third World suppliers of textile equipment. One could, of course, easily extend the analogy to include the firm's probable failure to explore ways of organising the transfer process to maximise learning by the recipient's personnel. The conclusions drawn above about the importance of establishing explicit types of choice criteria via direct and early management intervention would be the same.

There is some evidence in the secondary literature of a general awareness of this point and of the need for developing countries to acquire technological capabilities through the transfer process. For instance, virtually all UNIDO and UNCTAD documents make the point. Indeed, similar statements are to be found in many documents concerned with technological developers containing official Third World statements on technology transfer, even among the poorer, smaller countries. The beliefs are also likely to be held by managers of public enterprises - and perhaps even introduced (too late) into the negotiation stage. For instance, Broden and Mattson (1979) describes a case in Tanzania where the Tanzanian decision makers stated in fairly general terms at the beginning of the search for alternative suppliers that they wished the foreign suppliers to ultimately transfer the know-how required to locally manufacture trucks and railroad wagons. But since the Tanzanians apparently never took steps to further articulate how they wanted this to happen and in general did not push the issue very hard in negotiations, the desired transfer of technological capability in fact never came about.

Obviously, there is a large gap between statements about what is 'desired' and action to ensure that it occurs. And with very few exceptions there is little real evidence that most Third World enterprises are actually taking concrete steps towards acquiring Type B resources during technology transfer in this direction by giving high priority to these issues in the pre-investment phase. In fact, what little evidence we do have suggests that these firms traditionally seem to attach little or no significance to these issues when formulating and implementing transfer projects. We can give a number of examples which bear out this contention. The first comes from Venesuela where on the basis of their detailed study of state enterprises in the Venesuelan petrochemical and steel sectors, Avalos and Rengifo (1980) conclude:

> The most striking fact...is that these firms have little or no concern for the technological aspects of development...their behaviour has been clearly dominated by a perspective that only takes into account the immediate situation. The pre-eminance of...the objectives of production has pushed aside all other concerns. The stimulation of domestic technological potential has been sacrificed for the security that established goals will be fulfilled on time. The risks inherent in the participation of Venezuelan research workers or engineers in the design and installation of industrial plants, contrasted with the confidence

> inspired by the technological packages brought from abroad, have become the main brake on the development of local technological capacity. Thus the guiding thread in the negotiations of the purchase of technology lies in the weighing of risks.... This approach...has justified the 'technological passivity' of the basic enterprises. The contracting of turnkey plants in which the technology is acquired quickly and safely...(and was the only mode of technology acquisition used)...closes the door on the possibility of local learning...it blocks off a source of technological external economies, which are of undoubted importance to the industrial process of the country. (p. 77)

Another example comes from the work carried out by the Science Policy Research Unit of the University of Sussex on technology transfer in Asia. This project looked at the experiences of large scale Asian public firms and the emphasis they placed on acquiring technological capabilities during the technology transfer process by which their main plants were established. The responses of local managers to questions about the extent of training they had as an *objective* in the technology transfer process is shown in Table III. For only five percent of the firms surveyed did the training objective include anything more than a standard concern with operational skills; very little value was attached to the need to acquire skills going beyond this. Table IV reinforces this point by showing the distribution of training activities actually undertaken by these firms. It suggests that very few firms actually organise training as part of the transfer process, and even fewer altered that pattern in subsequent years. A more recent SPRU D.Phil study carried out in Bangladesh on the publically owned textile and pulp and paper sectors revealed a similar lack of emphasis on training being provided as part of the technology transfer agreement. (Ahmed, 1983)

This (very slim) evidence *does not* suggest that the transfer process *could not* have been organised *differently* and more training undertaken if this had been one of the recipient's primary objectives. Quite the contrary, it points to opportunities missed in this regard. Obviously, there could be (or would be in other situations) obstacles arising from supplier reticence to offer much training beyond operation standard. But the whole point of our argument is that recipient firms clearly do not normally have capability accumulation as an objective when they begin to plan their technology acquisition strategies. Therefore it is not used as decision making criteria against which to judge the opportunities and costs afforded by alternative technologies and suppliers *during the pre-investment phase*. If it actually were the case, such criteria could then be used to narrow down the range of technique/supplier combinations with whom serious negotiations could be initiated to those few who would be prepared to go some way towards meeting recipient objectives in this area.

TABLE III: TRAINING OBJECTIVES OF INDUSTRIAL FIRMS IN ASIA (1960'S early 1970's)

	Proportion of firms in each category	
TYPES OF RESPONSE ABOUT TRAINING OBJECTIVES	'Skilled Workers' Training	Technician Training
No training undertaken	4%	10%
To operate the facility	94%	54%
To operate and repair the facility	2%	15%
To undertake some form of change	0%	5%
Indeterminate response - perhaps indicating a concern with change	0%	16%
TOTAL	100%	100%

Source: Preliminary results, unpublished SPRU study

TABLE IV: SELECTED ASPECTS OF TRAINING ACTIVITY OF INDUSTRIAL FIRMS IN ASIA (1960'S and early 1970's)

	Proportion of firms carrying out:			
Types of Technological Training	No Training at all	"Marginal" Training Activity	Some Training During Initial Transfer Process	After Initial Transfer Process
For Process R&D	100%	0%	0%	0%
For Process Engineerng	98%	0%	2%	0%
For Process Maintenance	78%	12%	6%	4%
For Product R&D	98%	0%	0%	2%
For Product Design	96%	0%	0%	4%
For Product Quality Control	86%	10%	4%	0%

1 Indeterminate interview responses suggesting the possibility of limited types of training having been carried out.

Source: Preliminary results, unpublished SPRU study.

4. Local Control Over Decision Making

Another, and perhaps the most crucial point, which the above discussion has tried to bring out is the importance of being able to establish local control over the decision making process in the pre-investment phase. The opportunity cost problems highlighted by Amsalem's work are obviously going to be magnified if control of both decision making and task execution is in foreign hands. The reasons why local control of decision making is important should be obvious enough from the previous discussion and need not be repeated here. Unfortunately, it is just as obvious that many recipient firms commonly relinquish much of their control in this phase to foreign enterprises - either directly by giving them total responsibility for the project (i.e. turnkey projects) or indirectly, by allowing them to perform certain vital tasks such as feasibility studies and then being unable or unwilling to ensure that the recommendations as to technique and supplier are in the recipient's best interests rather than those of the foreign suppliers. The problem is widespread and acknowledged in many contexts. (For instance, see O'Brien et al (1981) for a discussion of these aspects in relation to Tanzania, the NISER (1981) for an example from Nigeria and Manikam (1979) for an example from Sri Lanka). The criticisms which are leveled at these cases frequently centre around the costs and problems associated with the blatant overcharging that often takes place, accompanied by massive cost overruns, long delays, extensive foreign involvement in operation and management of the project once completed, etc. etc. Although the question is not frequently asked, there is probably little doubt that if we assessed these projects on their contribution to capacity accumulation, the results would be equally discouraging.

Reasons for loss of control

There are a number of reasons why recipients fail to retain/exercise adequate control during the pre-investment phase. In many instances, maintenance of control over decision making is simply not given a high enough priority by overworked managers too busy to exercise effective responsibility and too willing to delegate their authority to 'competent' foreign firms. Managers are simply not aware/or are not concerned about the costly implications of any subsequent foreign involvment in the investment phase that might result from the use of foreign consultants in the preparatory phase.

Where the primary objective is to ensure the rapid and efficient installation of productive capacity, the use of foreign consultants in the pre-investment phase may make good commercial sense - particularly if the local skills do not exist or if the recipient has little confidence in those that do - and if the recipient is experienced and a strong partner. However, even then there are potential risks if too much freedom is granted. The use of consultants is likely to be most costly if the enterprise involved is not well established or is staffed by individuals with little experience in the mechanics of managing technology transfer. It is precisely in this situation where there is a strong rationale to use outside expertise - but an equally strong likelihood that this reliance will do little to rectify the skill shortages that created the situation in the first place.

The current structure of the international division of labour in the engineering and consulting market reinforces this trend. Many firms now specialise in performing the full range of pre-investment activities for recipient enterprises and actively pursue contracts of this sort. These firms can offer efficient and highly competent services which the recipient would be very hard pressed to meet on straightforward cost terms if the work was carried out locally or by internal staff. Yet where external consultant firms are engaged, it becomes very difficult to find the dividing line between carrying out a predetermined set of technical studies and exercising a persuasive degree of influence over the subsequent fundamental decisions regarding the project. This is particularly true where the recipient firm itself lacks sufficient skills to specify its requirements and undertake evaluation - in such situations managers are frequently anxious to fulfill their management responsibilities by letting the foreign firm perform these activities on the basis of totally understandable desire to minimise the risks they would face if they had to use local suppliers.

Historical links are also often quite important obstacles to the development of a decision making capability within an enterprise. It is commonly the case that once a consultant firm is engaged in a project on which it performs adequately, it often remains involved with the recipient or the project on a more or less continual basis. This is highlighted by Manikam (1979) in Sri Lanka where Sandwell Consultants, initially engaged as trouble shooters for an existing paper mill in 1959, were continually involved in the preparation of feasibility studies, tender documents, evaluation of suppliers' offers and management contracts over at least the next fourteen years.

Managers frequently do not reckon with the inherent logic that leads consultant firms engaged in preliminary work and feasibility studies to specify a set of technique/supplier options which may not be the optimal choice from the recipient's viewpoint - either because the consultants themselves tend to be limited (for geographic or other reasons) in the range of options they consider, or because they enjoy rather more 'direct' linkages with specific equipment and technology suppliers. The result can be a costly package. Perrin (1978) estimates that from a sample of Third World public sector contracts involving French engineering and consulting firms, for every $10.00 spent on the cost of the consultant's contract, the recipient was led to spend at least $1,000,000 on subsequently purchasing technology from suppliers specified by the consultants. The ratios may be different where other countries are involved, but the linkages are very common.

The NISER case study of a fertiliser plant in Kaduna, Nigeria, provides an excellent example of these sorts of linkages and

TABLE V: LIST OF MAJOR CONTRACTORS ENGAGED IN THE IMPLEMENTATION OF A SUPERPHOSPHATE FERTILISER PLANT IN KADUNA, NIGERIA, LATE 1970S.(1)

Task Description	Company Engaged	Country of Home Base
Feasibility Study	Japan Consulting Institute	Japan
Appraisal of feasibility report and of project proposal	International Executive Sevice Corps	USA
Equipment supplier and installation (Turnkey Contract)	Hitachi sosen	Japan
Technical management	Hitachi sosen	Japan
Civil works	Local companies	Nigeria
Monitoring consultant	Haldor Topsoe	Denmark
Adviser to Federal Government on Monitoring Contract	NISER[2]	Nigeria

1. The total capital investment in the plant amounted to $25.6 million up to 1980 and this was financed entirely by the Federal Nigerian Government.

2. Nigerian Institute of Social and Economic Research at the University of Ibadan.

Source: NISER, 1980, p. 46

constraints. Though the plant itself was entirely financed and owned by the Nigerian government, virtually the entire responsibility for decision making as well as for implementation was turned over to foreign, especially Japanese, consultants as shown in Table V.

The report argues that:

> It will be noted that the feasibility study was carried out by a Japanese company, the equipment supply and installation contracts went to a Japanese company, and of course the technical management contract also went to a Japanese company. Since the feasibility/ project study, equipment supply, and management contracts together make up the technology for the project, it appears that the technological choice decision making in this project has a very strong Japanese content.
>
> This situation is typical of most industrial projects in the public sector in Nigeria where the advisory role of the technical consultants is effectively a decision role, and the only decision

> left for the government officials is a price decision. Even in this case the effectiveness of the officials' decision is limited by lack of information and a rather strange lack of foreign competition due to excessive tailoring of the recommendations from the feasibility or project study to preferred clients. (NISER, 1980, pp. 45-46)

As a result of the extensive involvement of foreign suppliers, there was very little effective transfer of technology and the NISER report points out that 'the skill to plan, install and operate the plant was imported and it is likely that a new SSP plant today would probably have to import the skill required to perform these same tasks'.

As the report shows, these problems clearly stem from the recipient enterprise's failure to exercise adequate rigorous control over decision making in the crucial preparatory phase when the technology and the suppliers were being selected.

5. Foreign Consultants and Foreign Aid

It would obviously be an oversimplification to suggest that recipient ignorance of the costs of relinquishing control is always at fault. Other constraints can very severely circumscribe the ability of the recipient to exercise control in the preparatory phase. Perhaps the most immediately obvious constraint exists when external financing is required to support investment projects. The financial problems associated with the technology supply and tied aid are well-known - we only wish to highlight that these linkages frequently extend back to the pre-investment phase where the financing institution often requires that internationally recognised consultants are engaged to undertake feasibility studies and be involved in the tender process.

This aspect is highlighted rather well by Desai's (1972) analysis of the experience of the Bokaro Steel Plant in India. Initially, the overall design and engineering of the plant was to be carried out by an Indian consulting firm - Dastur and Company. This group was to be responsible for the detailed design and planning embodied in the project report, for specification of equipment and structural items, and for the preparation of manning lists, job specifications, recruitment schedules, training programmes, and required syllabi and manuals. It was to handle the procurement of equipment, etc., the management of construction, and the installation of equipment (including overall supervision of equipment installation by foreign suppliers). Thus, although a significant proportion of the equipment for the plant would be imported, both the overall techno-managerial services and a major component of the engineering services and capital goods were to be obtained from within the Indian economy - this was an objective specified at the very beginning of the pre-investment phase.

Although there had already been Indian involvement in parts of earlier investment projects, this plan marked a significant step in the transition towards localised supply of technological inputs for investment in an industry that was expected to continue its expansion. However, it was proposed initially to seek US aid-financing for the foreign exchange component of the project. Although this never happened, affairs proceeded far enough to indicate some aspects of what might have been involved. In the early 1960s Dasturco prepared a detailed feasibility study report, while the US Steel Corporation also prepared a similar feasibility study for the project. Some features of the results of these studies were:

- plant capacity was similar: 1.5 million tons (Dasturco) and 1.4 million tons (US Steel)

- total investment cost was lower in the Dasturco proposal: $751.5 million, compared with the US Steel estimate of $919.4 million

- the foreign exchange component in the Dasturco proposal (42%) was lower than that in the US Steel plan (55%), and consequently the total foreign exchange cost of the more expensive US Steel plan was about 60% larger than in the Dasturco proposal

- the Dasturco proposal envisaged 30-40 foreign technicians to assist the Indian operating company for a short period after construction; the US Steel report proposed that the management be entrusted to an American team for a period of ten years, which at one point would involve a team of 670 American technicians!

In other words, the use of foreign consultancy and design would probably have resulted in this case in a production facility which, relative to the locally designed equivalent, was more capital intensive and more import intensive, and would have involved substantial loss of operating control. It is evident also that the proposal to seek foreign consultancy and design services would have led to efforts being made to establish foreign control over the investment phase as well as over the subsequent operating phase. A senior official of the US aid agency indicated to a Congressional Committee that:

> We would not be prepared to go forward with this proposition until we had worked out a satisfactory understanding with the Indian government as to US personnel controlling the design of the mill, construction of the mill and a management contract for a period of five to ten years. (Desai, 1972, p. 31)

In a similar vein, the Executive Vice-President of the US Steel company indicated to the same committee:

> There is in India a reasonably good force of consulting and design engineers, but we think that while they would be entirely competent to carry out detailed design work, for a large and modern mill of this sort which would employ US equipment, US engineering should be used.... The construction should be handled by large, competent outside concerns which can provide the

> supervision, the equipment, and the coordination that is necessary to progress any large job satisfactorily. (Desai, 1972, p. 32)

Thus, given the commitment to seek finance from outside (at least, to seek it from the US) the accumulated technological capacity in India relating to steel industry investment would have had to face these pressures. In effect, these would have operated to block the transition towards internalised technology supply at the point where that process crossed the discontinuity between detail engineering and the execution of overall design and management.

In the event, in this case, commercial interests in the US together with ideological interests (opposition to the financial assistance of public rather than private sector industry in India) generated in the US a body of political opposition to the project as a whole. Recognising this, the Indian government turned to an alternative source of finance - Russia.

A similar but less complex situation is highlighted by the Manikam study cited above which in trying to explain why the recipient, over a twenty year period, relied almost exclusively on foreign consultants to prepare feasibility studies pointed out that:

> From the early sixties, when the balance of payments situation deteriorated, no major project could be established without foreign financing and the foreign lending institutions invariably insisted on feasiblity studies from recognised (international) consultants. (Manikam, 1979, p. 34)

Since economic growth and internal accumulation is slowing down severely in many countries, it is only too clear that the power of foreign sources of finance to impose restrictive and unfavourable conditions on recipients will continue to grow. Very little explicit attention has been devoted towards either researching or developing an effective strategy vis a vis aid flows and technology transfer.

LECTURE SIX

PREPARATION AND SEARCH: THE IMPORTANCE OF DECISION MAKING IN THE PRE-INVESTMENT STAGE OF TECHNOLOGY TRANSFER: II

Introduction

In Lecture Five, I argued that the nature of the decision-making process in the pre-investment phase was a particularly crucial determinant of the potential contribution that new investment projects could make to the accumulation of indigenous technological capacities. I then reviewed a number of factors often present in a developing country context that tend in fact to limit the scope for pre-investment activities to actually make such a contribution. In this lecture, I want to shift from a problem-focused analysis to explore a variety of mechanisms by which Third World enterprises and governments take steps during the pre-investment phase to create learning conditions throughout the whole of the technology transfer process. In the first section, I examine some means to overcome the problem of skill constraint within the decision-making and activity streams. In section two, after reviewing the role of 'political committment' various types of information generating activities are outlined that are essential to effective decision making and central during the transfer process. And in section three the key issues of search, evaluation and supplier selection are discussed.

1. Overcoming the Skill Constraint

I alluded earlier to the pervasive constraints that skill shortages place on the ability of many Third World recipient firms to exercise effective control during the pre-investment phase. Frequently recipients simply lack the trained manpower necessary to carry out the decision making and technical tasks. The problem is compounded by the less than ideal conditions under which projects are prepared and processed in the early stages. Skill shortages in the enterprise or government agency create the need to hastily assemble a project team from whatever expertise is available; these skills are often either marginally relevant to the project at hand, or else the people are so overcommitted that they are not able to spend adequate time on the project. This problem is compounded by the fact that the project team is likely to be under extreme pressure from the ministry responsible (or the aid agency involved in providing financing) to act quickly so that the investment phase of the project can begin as soon as possible. Under these conditions, heavy reliance on outside experts (particularly if the aid source is applying pressure in that direction) is virtually a foregone conclusion. Yet even though the existence of these problems is perhaps understandable, there can be little doubt that this situation can have high opportunity costs in both financial and social terms.

These sorts of problems are well known and there is little need to detail them here. In such circumstances, simply suggesting that what is required is more skilled people and better conditions for project preparation is almost certainly of little use. However, I have mentioned the existence of these conditions because it reinforces my arguments about the need to exploit the learning potential of the transfer process - particularly in the pre-investment phase. There are mechanisms which can be used for this purpose. A crucial first step is to establish a competent preparatory team. In assembling the team the aim should be not only to ensure that it has the skills to provide the necessary guidance and support to the firm's management in making major decisions and in organising the subsequent implementation of the project; perhaps even more important it should be intended to act as a repository of pre-investment phase expertise for subsequent projects. As such, the team can be constituted in a way which maximises the learning benefits to be gained from coordinating the pre-investment phase, as well as having as one of its objectives the design and organisation of investment phase activities that have a similar emphasis on learning.

The team might well be multi-disciplinary consisting of engineers, technicians and economists, as well as senior managers with decision making responsibilities from within the recipient firm - though it might also be useful to involve individuals from other local institutions which might benefit from the experience. If such individuals are not available within the enterprise or locally, outside expertise will have to be bought in. Ideally such outside experts should work within the recipient enterprise rather than on an arm's length consultancy basis, and should have equal local counterparts working alongside them to maximise the learning opportunities for the recipient as well as ensuring local control over the project.

Girvan (1981) has described another mechanism to capture learning benefits in the pre-investment phase which is referred to as 'parallel contracting'. When this technique is used, the recipient organisation awards contracts for the same consultancy, design or engineering work simultaneously to a local and a foreign firm. The local firm involved may make arrangements with other foreign organisations for the supply of specialised know-how, but it must undertake to do the technical work - design, calculations, specifications, etc, itself. The same technical work is carried out by a foreign firm, whose report is then used as a means of checking the work and standards of the local firm. In turn, the report of the local firm can also be used to evaluate the recommendations of the foreign firm and so, for instance, the mechanism can also serve to assess the appropriateness of the technology or technology supplier specified by the foreign organisation.

This strategy has been applied in a number of countries such as Mexico and Yugoslavia. For example, in the Yugoslav copper mining industry all projects for new plants and installations carried out from 1950 to 1957 were designed within Yugoslavia even though many were also handled by foreign companies. This did not mean that the country was in a position to rely exclusively on its own scientific and technical resources. On the contrary, it was necessary to farm out parallel contracts and to rely on specialised foreign consultants and experts.

> In selecting machinery, equipment, and other installations, which were of necessity imported, the RTB (state copper mining company) carried out its own studies, had others performed by Yugoslav companies and, at the same time had others carried out abroad under contract by firms of specialists. This form of parallel contracting was, and is one of the most important of the channels open to Yugoslavia for training high-level professionals. (Junta 1976, p 30).

Here the extra costs incurred by parallel contracts can be seen to be more than compensated for by the value of the training received, and by the savings realised in reducing errors and improving the quality of the technical work serving as the basis for the execution of large and expensive investment projects.

2. Steps to Maximise the Learning Benefits from the Transfer Process

There are many dimensions to the manner by which public sector enterprises might begin to use preparatory phase activities to create learning conditions during the investment phase. Certainly the first (and possibly the most important) is the existence of a commitment to this objective among management and decision makers. Though the notion of 'commitment' is an evocative concept (and one that can easily be dismissed) there is little question that it has been on of the key ingredients of those cases where effective technology transfer has taken place.

For instance, Sabato (1973) describes the efforts of Argentina to establish a nuclear power programme. His article lays a great deal of emphasis upon the deliberate steps that the Argentine nuclear authority took in building upon indigenous capability in some aspecs of the technology. Sabato stresses that:

> The foremost objective of Argentine atomic energy policy has been to build up an autonomous decision-making capability... Argentina's autonomy as a sovereign nation can only be deployed if it has the proper know-how to choose and decide. (p. 25)

When it came to planning the construction of the power plant at Atucha, one area where that decision making capacity was exerted was in relation to the supply of fuel elements: "It was then decided that offers ought to include explicit reference to the manufacture of the fuel elements in Argentina." In fact, the selection of West German over Canadian suppliers was based precisely on the former's willingness to transfer fuel element technology in the face of Canadian intransigence on the same point.

More generally, even though the main design and engineering services and capital goods were to be imported:

> ...CNEA was deeply interested in making Atucha the point of departure for a nuclear sector in Argentine industry. To achieve such a purpose CNEA specified that the offers for the Atucha project ought to contemplate a maximum participation of the local industry, covering not only traditional items such as civil engineering, ancillary services and the like, but also important components of advance design and technology. (p. 32)

These objectives were maintained through the negotiations with alternative suppliers, and played a significant part in assessing the final offers. In the end, local inputs accounted for about 35% of the cost of the project.

In another case involving the petrochemical industry in Brazil, which we shall be discussing in more detail below, Sercovitch (1980) stresses that the fundamental reason for the success of the transfer of technological capabilities was the massive commitment to the concept on the part of PETROBRAS, and its willingness to invest a substantial amount of resources to achieve it.

Hence, the importance of 'commitment' is not an empty rhetorical concept. But obviously, beyond simply making a political commitment much more concrete steps have to be taken. Many of these involve the generation of information of various types. As a general principle, there would be a need to disaggregate the different components of the project by trying to define these in terms of both embodied (equipment, blueprints, specifications) and disembodied technological inputs. It seems to me that such a listing provides an essential starting point for defining recipient needs under the capability heading. This listing would need to be produced as early as possible in the pre-investment phase and in as much detail as possible. If the knowledge to do this is not available, then presumably its generation could be one of the stipulations of the terms of reference for the feasibility, if not the pre-feasibility studies. It is quite easy to see that such a disaggregation would literally require its own separate exercise rather than being part of another study - this would in itself be a useful learning exercise since the degree of technical expertise needed to disaggregate a project in this way will obviously be considerable.

After disaggregation, some type of ranking would have to be attached to the different elements that indicate the priorities of the recipient vis-a-vis acquiring one type of input over another.

The way in which the recipient ranks these inputs would partly depend on the reasons why the enterprise is acquiring the technology and the context of its use, as well as the relative availability of the skills locally. For instance, an export-oriented firm may decide that it needs to acquire best practice techniques to stay competitive internationally - if this is the case it may also decide it needs to acquire the capability to adapt and generate innovations on the basis of imported techniques. The types of skills required in this case will differ quite considerably from those needed simply to operate and maintain the system, or to produce certain pieces of capital equipment. Similarly, if the national plan proposes to erect successive plants (requiring similar inputs) over a number of years, for the first plant it might choose to concentrate its capability acquisition strategy on a particularly important set of skills or a key type of process know-how which could be used as the basis for more extensive local participation in subsequent projects. The precise delineation and ranking of such capability/input requirements will naturally be a time consuming process, becoming more complex as the preparatory phase moves forward and ever more specific requirements are identified. Consequently, it will be necessary to get the process underway as soon as possible in the pre-investment phase.

The second major type of information required would be a survey of the relevant skills/capabilities which are available either within the recipient or among local suppliers. The survey would need first to identify and evaluate available skills which are going to be immediately adequate to meet the requirements of the project. In some cases, existing technical capabilities may need to be upgraded and steps can then be taken, either directly or through government intervention to assist local suppliers to meet demand, at the required time.[1]

Such an inventory would, of course, also highlight the gaps that exist in the local pool of resources and as a result either total reliance on the supplier would be necessary or else the transfer process would need to be used as a learning vehicle to provide the skills to meet requirements in subsequent transfer events.

Once the enterprise has a clear idea of the capabilities required to undertake the transfer project it is considering and possesses an assessment of existing or potential capabilities in this area, it can begin to devise its approach to negotiation and the subsequent investment phase. It is at this stage that the recipient can determine the degree of unpackaging it wishes to achieve; identify the tasks that the supplier should undertake and those that it should undertake; determine the sort of training or actions it needs to commence in order to ensure that local skills are available (and suitable) at the right time; and finally devise a negotiating strategy to ensure that enterprise engineers, technicians, etc are included in the supplier's transfer activities in such a way as to facilitate the real transfer of technical know-how.

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1. This further implies the need to develop a clear specification regarding the scheduling of the project since this will give some idea of the time horisons that need to be taken into consideration in planning the training programmes needed to ensure that sufficient skills of the right type are available at the appropriate time.

Obviously enough, resource costs will be involved in the use of local technology suppliers or in gaining supplier acquiescence to allowing learning processes to take place during the investment phase. Both social and private costs of a possibly substantial nature may be incurred in trying to use local suppliers who, for instance, may not be able to meet the technical specification required of them. Foreign suppliers, too, may choose to increase the price of their technology if asked to bid on projects where, for instance, they are expected to carry out training in novel or sensitive areas. Benefits on the other hand may also be considerable if the recipient is able to confidently source its requirements from local suppliers charging lower prices than foreign firms.

In relation to this point, a third, particularly important exercise that will need to be carried out is the analysis and assessment of the costs and benefits likely to stem from attempts to develop capabilities through the transfer process. Wherever possible, such flows should be quantified in order to demonstrate to the recipient's management (or to the government) the sort of return likely to accrue to investments in this area. For the public sector, a clear idea of the type of external economies likely to accrue will be necessary to justify this sort of investment. Obviously, it may prove extremely difficult to quantify these flows, though the capabilities are probably easier to pin down than the subsequent benefits likely to flow from investments in learning during the investment phase. Nevertheless, since resource allocation can only be justified on the basis of returns to investment, I believe that these efforts to try to quantify the gains must be made by the enterprise - otherwise it may simply be unable to persuade the government to support such a programme.

3. Search, Evaluation and Supplier Selection

The activities described above must be carried out as part of an iterative process of search and analysis which goes on through the entire preparatoy phase. The 'search' component is particularly important since much of the information needed to do to the sort of detailed analysis we have in mind can only be provided through successive rounds of interaction with technical experts and suppliers.

Many Third World recipients, of course, adopt a passive approach to information acquisition in the preparatory phase (e.g. the example of the textile plant engineers in Lecture Five). They are unable or unwilling to generate adequate information from available resources and hence turn to the services of foreign consultants. However, if the objectives of the preparatory phase are to develop an informed 'in-house' knowledge of the techniques available, the degree of unpackaging that is technically feasible and of the types of capabilities required to provide the technological components of the project, then efforts to acquire that knowledge will need to extend well beyond local sources. Such search efforts become both a source of technical information as well as an important learning vehicle in their own right. As the teams become more familiar with the technology involved they will be able to be much more specific with the questions they pose and the answers they are prepared to accept.[2] And though obviously important as part of the preparation for specific projects, search activities should ideally also become part of an ongoing process of information generation and the internal accumulation of capabilities undertaken by recipient enterprises. Junta (1976) contains descriptions of search efforts undertaken by enterprises in Yugoslavia, Japan and Czechoslovakia who have used overseas visits to build up both their general and specific expertise with regard to the technologies they use. In discussing the historical antecedents of the now technologically 'self-reliant' copper industry in Yugoslavia, the report points out that:

> The few scientists and technicians the RTB had at its disposal at that time undertook a campaign to survey the techniques to be used in designing new projects and extending those already in operation. This entailed, as a primary measure, an active review of existing techniques: the extent of this survey may be gauged from the fact that, by the end of 1957, 40 countries had been visited. (p. 30)

The same report includes a description of the technology policy underlying the development of the machine tool industry in Czechoslovakia. The Machine Tools and Machinery Research Institute played a significant role in this development, and used extensive search procedures not only to identify knowledge and information, but to provide a basis for selective 'international scientific and technological cooperation'.

> During the past 10 years[3] alone, experts from the Machine Tools and Machinery Research Institute have carried out 380 study trips and visits to factories, institutes, exhibitions, seminars, and other events and institutions in 26 countries. The observations and results of these visits are worked out in the form of travel reports and stored in the memory of the computer for subsequent use in the information system, which also includes experience gained in the following activities: international congresses and symposia (organised by the Institute) on automation and programming in the machine tools industry, model techniques in the metal working industry, and other subjects connected with the machine tools industry; scientific cooperation with research centres and institutes abroad; and visits of foreign technicians and experts to the MTRI, which has, over the past 10 years, received about 1700 visitors from 34 countries. (Junta 1976, p. 39)

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[2] Sercovitch (1980) brings out this point very well in his description of search activities undertaken by Petroquisa.

[3] The report was prepared in the early 1970s.

In this case the more widespread application of the results of the travel activities is related to the fact that the activities are undertaken not by a single enterprise but by an institute servicing the entire publicly owned industry.

Another example from the report relates to the efforts of MITI in Japan to set up a petrochemical industry. Four firms were chosen to be the basic conduits by which petrochemical technology was to be acquired and assimilated. As an initial step in creating appropriate conditions for this assimilation, each firm:

> ...established a planning and development department initially with a staff of 8 - 10 professionals. These were entrusted with the responsibility of surveying and selecting the four or five basic techniques required to set up the company's first petrochemical plant. (p. 23)

Prior to negotiations with specific suppliers, these teams set out to develop a basic working knowledge of the technologies available, of the in-house conditions that would be necessary to facilitate assimilation and of the nature of international market conditions in which they would have to negotiate. Much of this work was done on the basis of overseas visits to suppliers and customers.

This point highlights an additional component of the type of technological survey discussed above. When undertaken in relation to a specific project, such a survey not only provides information regarding the range and nature of the technical options, it also necessarily widens the range of suppliers under consideration - indeed this should be an explicit objective of the survey. By expanding the range of options considered, the recipient will (probably) considerably improve the opportunities open to it of engaging in an effective transfer process with a willing and suitable supplier. By way of emphasising these points we can quote the Andean Pact report cited above which draws on the lessons of the case studies it prepared in arguing that firms in the region should adopt:

> An active attitude [which] involves conscious weighing of technology alternatives in accordance with the requirements and priorities at the national or sub-regional level: in other words, an attitude that directs the technology consumer towards the international market of technology suppliers and leads to an increased understanding of the alternative techniques and sources available, their market conditions and technology proper.

In economic terms, it could be argued that firms need to expend resources on exploring the range of alternative techniques and suppliers up to the margin where the costs of considering additional alernatives equals the likely returns.

However, in reality, most Third World firms usually fall far short of this in their search efforts. For reasons associated with high resource cost, severe time pressure, personnel shortages and simple inefficiency, these recipients are often content to rely on suppliers to come to them. Examples of this were given in Lecture Six - another pertinent one also relates to Brazil where a study carried out by MIT in the mid 1970s showed that in a sample of well over 500 firms (50% in the public sector) - 46% considered no other technology supplier than that which they used, 26% considered two alternatives or less - indeed among those that did consider alternatives, none included local sources.

I am suggesting that in direct opposition to this passive approach that a considerable portion of the pre-investment phase activities be devoted explicitly to efforts to broaden the range of options considered. However, I am going much beyond this in suggesting that the recipient must also aim to use the information gained to allow it to approach prospective suppliers with a clear idea of what it wants from the transfer process in terms of addition to both its productive capacity and its technological capacity. By using the preparatory phase to draw up a 'shopping list' of its technological requirements and to develop strategies for organising the learning dimension of the transfer process, the recipient's initial bargaining position will be enhanced. Suppliers can be vetted according to their willingness to enter into negotiations on a clear understanding of the recipient's requirements. Similarly, the precise configuration of technological components that will make up project can be (where possible) developed and organised in order to create maximum opportunities for local sourcing and local learning.

This approach has rarely been adopted outside of a few enterprises in the more advanced developing countries. It is my expectation that if it were adopted by more countries, recipients would create much better opportunities from which to use the transfer process to develop local capabilities. A good note to close on in this regard is an observation drawn from the Andean Pact report mentioned above. After carrying out the case studies mentioned earlier, the Pact's research team then set out to discover what sort of search effort and criteria had been applied by firms importing technology into the iron and steel sector. They discovered that throughout the Andean sub-region, technology was imported in packaged form, without acquisition of the knowledge and skills that lay 'behind' the packages. The technology policy group of the Andean Pact Secretariat set out to find out the extent to which this was a necessary fact of life. With respect to the possibility of importing the knowledge underlying equipment and plant imports, they reported that:

> ...the mission...wished to find out the position of the major manufacturers in respect of the sale of designs and of the most essential parts of their machinery so that these could be manufactured in the sub-region if feasible.
>
> In nearly every case, the response was favourable.... All of the manufacturers consulted, without exception, were willing to supply

> the designs of any parts that could be manufactured within the country purchasing machinery from them. (p. 100)

Comments of this type could be replicated many times over - with respect to other sectors in relation to other countries. In short, because many recipient firms in developing countries adopt a passive attitude to technology search they fail secure access to core technological know-how that is essentially available to them if only they were prepared to ask for it! They remain content instead with acquiring only Type A flows. However, this does not have to be the case. To illustrate this point I want to consider in some detail the technology transfer strategy that has now been adopted by Brazilian state enterprises operating in the petrochemical sector.4

4. The Case of Technology Acquisition by Petrobras

In the early mid 1970s Brazil through its state enterprises Petrobras and Petroquisa established two world scale ethylene plants to meet domestic demand. The first plant was set up via a packaged, turnkey deal with very little local involvement in engineering (0%) or equipment supply (30% local supply). The second plant saw more Brazilian involvement in engineering (54%) and capital goods supply (65%) but not in basic engineering and process know-how.

When the decision was taken to build a third world scale ethylene plant, Petrobras and Petroquisa undertook a major departure from their previous technology acquisition strategies. Instead of simply acquiring productive capacity and rather passively expanding their local involvement, they decided not just to continue to substitute domestic for foreign hardware and engineering services but also to attempt a technology transfer which would allow them to

> ...fully appropriate, both in technical and legal terms all assets and skills related to state-of-the-art process know how, process design engineering and R&D in the ethylene field. (p. 23)

Such a strategy necessitated a very different approach to the problem of finding a suitable technology supplier. Petrobras were not only looking for someone with the right technology - the firms equally had to be prepared and capable of effecting a full and complete transfer of their core in the pre-investment phase technology (Type B flows). The whole orientation of preparatory activities was therefore devoted to identifying the right technology/supplier combination according to the criteria specified above. To do this, Petrobras first carried out its own extensive survey of the different technologies available to produce the type of product in which Perobras wanted to gain state-of-art expertise. In doing so it ascertained that one type of technology

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4. This section is based on Sercovitch (1980) and all the quotes are from this paper.

was most suitable and that this was in turn available primarily from four suppliers worldwide: Linde (Germany), Lummus (USA), Stone and Webster (USA), and Technip/KTI (Holland and France). Petrobras issued a call for bids on a project with two components. The first element of the bid was standard and related to the design and construction of an ethylene plant, and the second was much more unusual for it contained an explicit call for these firms to submit bids associated with ensuring the full and complete transfer of all the process know how to Petrobras.5

After the bids were submitted, Petrobras evaluated them in Brazil but before making the final choice of supplier, they entered into an extensive series of negotiations with the four suppliers in their own countries. The process of these negotiations as described below by Sercovitch illuminates precisely the sort of approach to the pre-investment phase that I have been discussing throughout these two lectures.

> Before making the definite choice of technology and basic process engineering supplier, CENPES's officials spent several weeks visiting the US Germany and France. During their visits, they assessed what the bidders had to offer...then they proceeded to negotiate that content upwards by successive approximations to a deal involving as complete a transfer as possible...[and] advanced towards increasingly high degrees of specificity in what they required. This way they covered everything from computer routines to material balances, and from there to simulation programmes, and so on...the process took about two months of continuous negotiation during the first stage. (p. 38)

That process narrowed down the group of potential technology suppliers from four to two, Stone and Webster and Technip/KTI. The other two firms, Lummus and Linde, dropped out because they were not prepared to meet Petrobras' demands regarding the transfer of process know-how and other elements of technical knowledge. Petrobras negotiated a further two months with Stone and Webster and Technip/KTI and the contract finally went to Technip - although the preparation of the contract with Technip took two more months of negotiations. Its important to note that all of this effort and many hundreds of manhours were invested by Petrobras even before the technology transfer process proper began.

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5. This request had the power of law as it was backed up by a decree passed by the National Industrial Property Institute (NIPI) which stipulated among other requirements, the transfer contract must include the delivery of all technical engineering data for process and product, including the methodology used to obtain these data, their updating, promises of technical assistance.

The approach adopted by the Brazilians to the acquisition of technology is clearly an innovative one that represents a new departure from customary technology licensing agreements which are negotiated and designed not to maximise the learning process but simply to establish productive capacity. In these sorts of transfer arrangements some learning may take place as a byproduct of the transfer process but it is not deliberate and usually occurs very slowly.

The deal that Petrobras concluded with Technip/KTI in fact has reversed this process:

> The recipient's technological learning is not left to come out just as a byproduct of the deal. Rather, it is placed at its very core...the most active phase of the learning process does not begin once all engineering stages have been completed and the plant is ready for starting but...when the basic process design engineering work starts...learning is not normally focused on specific localised bits...but on the whole bulk of knowledge involved of all stages from the drawing board to the operating plant. (p. 36)

Achieving this degree of involvement in the transfer process was the objective that Petrobras pursued when formulating and implementing its pre-investment strategy.

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I would like to draw out some of the more general implications of the Brazilian experience by way of summarising my discussion in Lectures Five and Six. First, the emphasis that Petrobras placed on acquiring technological capacity through the transfer process underlines the arguments we made earlier about the importance of exploiting the learning potential of the transfer process. Second, the strategy followed in the pre-investment phase (which involved preparation, search and bargaining activities) clearly the crucial element in allowing Petrobras to identify the suppliers prepared to provide the sort of access and training necessary to fulfill their learning objectives. The fact that the other candidates pulled out of the negotiations because they refused to allow such access demonstrates the crucial importance core technological know-how. Thirdly, the committment that Petrobras clearly exhibited in pursuing the deal and in investing heavily in the learning process in the pre-investment stands in sharp contrast to the experience and attitude of public sector enterprises in other countries such as in the Venezuelan case described earlier, where the accumulation of technological capacity is not considered a primary objective of technology transfer and where as a result crucially important learning opportunities are constantly being missed and foregone.

Clearly, Petrobras is a special case. It is a large, successful and technologically very sophisticated public enterprise. It started the whole process described above from a strong position that almost certainly cannot be matched by most other Third World state enterprises. Nevertheless, the approach taken and the steps followed provide some valuable insights into the way in which recipient firm and the supporting government institutions can organise pre-investment activities to maximise the learning potential of technology transfer.

LECTURE SEVEN

PRICES CONTRACTS, CLAUSES AND CONTROL: BARGAINING AND TECHNOLOGIES CAPACITIES IN THE TRANSFER PROCESS

Introduction

In this lecture, I want to move the focus of our concern with the pre-investment phase into an analysis of the bargaining process itself. In Lectures Five and Six, although I may have given the impression that bargaining had little impact on the ultimate contribution of the transfer process to capacity accumulation - in fact I was simply trying to compensate for the overwhelming amount of attention bargaining and short-run cost issues in general received in the literature and in policy debates in the 1970s. Bargaining is obviously an important part of the whole transfer process and in this lecture I would like to look at this issue as well as related concerns with restrictive clauses and other short-run problems. As in previous lectures I will retain my underlying concern with issues of capability accumulation.

Unfortunately, the relationship between bargaining and the accumulation of technological capacities has not been given adequate treatment in the literature or in policy research. This is because, as I pointed out in Lecture Three, of the focus of the development community on the high price of technology and of their subsequent desire to find ways to reduce this price. This biased concern then with price created gaps in our understanding of the role of bargaining in the transfer process that even to this day, the large number of studies carried out have only been able to partially fill. For instance, the analytical literature has tended to formalise the bargaining process into models based on game theory. In effect, these analyses set the upper and lower price limits faced by the buyer and seller and define the factors which infuence the two parties in the process of reaching a mutually acceptable agreement. The models are then used to predict the 'outcome: of the bargaining situation which is usually defined in terms of a single agreed price. These sorts of analysis have been severely criticised for their inadequate and frequently incorrect simplification of a complex process into a situation where buyer and seller are adjudged to be of equal strength and to be concerned solely with price. In fact I shall show in the next section, where technology transactions are involved, bargaining takes place over a range of issues in addition to price, many of which may be of equal or even more importance to the buyer and seller. In seeking to define the abstract principles of behaviour in the bargaining situation, the analytical literature tends to obscure rather than illuminate many of the most important issues which are involved.

There is however a second stream in the bargaining literature of studies that are concerned with the empirical analysis of real situations (See Phillips 1976, Kaplinsky 1976, Desai 1972). This literature somewhat overcomes the problems of abstraction described above and tends instead to emphasise and assess the conflicts of interest which arise between buyer and seller over particular issues. Hence, these studies, by detailing the sequence of events and specifying the wide range of factors impinging upon both actors have provided a valuable counter balance to the myopic focus of the analytical literature. In particular, these case studies have usefully demonstrated that political economy factors are frequently more important in determining the outcome of the bargaining process than the strictly economic variables emphasised in the analytical studies.

1. Restricted Scope and Limited Coverage of Technology

However, despite the valuable insights provided by the empirical literature, there are still limits on the scope of our knowledge in this field. These constraints are particularly problematic in two areas; the range of seller-buyer contractual relationships situations on which we have empirical data, and the specific nature of contractual negotiations that take place over what might be called the technological elements. Most of the empirical case studies mentioned above centre on technology transactions which involve transnational corporations as the seller and developing country government or a large public enterprise as buyer. Transactions where these sorts of entities are on opposite sides of the bargaining table tend to exhibit a particular set of characteristics which distinguish them from the bulk of transfer activities which occur between North and South. These transactions (between TNCs and developing countries) often involve large scale and sometimes complex production processes which rely on a fairly high degree of sophisticated technical knowledge. The projects are usually of quite long duration and require sizeable amounts of capital expenditure in both absolute terms and in relation to the average level of investment in the economy as a whole. Finally because of the notoriety accorded to the transnational corporations in the literature and in the popular press, any project in which they are involved tends to attract a disproportionate amount of attention and emotional response.

However. as I noted in Lecture Three, many other types of supplier and recipient are involved in technology transactions; unfortunately our limited knowledge of these cases means that one can only speculate as to the importance of bargaining in determining the nature of the costs and benefits which flow from these activities. As Cooper and Maxwell pointed out in their 1975 study, there was a presumption that little or no bargaining occurred where relatively straightforward purchases of machinery are involved. In point of fact there is, as these researchers were able to show considerable evidence to suggest that even these apparently simple transactions are significantly more complex (and costly) than was previously assumed in the literature. If this is so (and we must stress that there are very few case studies available on this form of transfer) then it is likely that some form of bargaining must take place.

The same argument can probably be applied to those transactions where independent buyers and sellers are involved and in which some form of license agreement is reached between the two parties. A good deal of information exists regarding these sorts of transaction but, as we shall see in the next section, this information primarily consists of the ex-post details of the final contractual agreement rather than any assessment of the bargaining process which culminated in the contract. We know, of course, that a number of countries have some form of institutional mechanism for vetting and approving technology contracts. Studies of the performance of these registries have shown that a certain number of contracts are rejected because they contain restrictive clauses and terms which are forbidden by law. Leaving aside questions about the effectiveness of this procedure, it would appear these rejected contracts are frequently negotiated and successfully resubmitted to the vetting agency. Unfortunately, once gain we have little information on the nature of the re-negotiations which must both occur between buyer and seller, and between these firms and the vetting agency.

I would argue that this general lack of detailed information about the nature of the bargaining process has become increasingly costly as the incidence of arm's length transactions has increased over time. Policy makers trying to devise interventions to improve the conditions under which technology is acquired in these conditions have thus had to formulate policy on the basis of inadequate information and possibly incorrect assumptions.

These problems are likely to be particularly acute if the government hopes to improve the technology related rather than price-related aspects of the transaction. Once again, lack of empirical information causes difficulties for any attempt to conceptualise the role of technology in the bargaining process. I have argued throughout this series of lectures that the key feature of technology transfer is the way in which this process impedes or assists the accumulation of local technological capabilities. The twin assumptions in the bargaining literature (and the underlying policy debate) that price is the most important issue and that bargaining determines the price tells us very little about the interaction between transfer of technology and capacity accumulation.

In particular is is generally not at all clear what, if any, sort of negotiations take place over the specifically 'capability relevant' elements in the transfer agreement. Some of these elements would be the nature and extent of training provided by the supplier; the degree of access to 'core' technical knowledge; the extent of recipient participation in the transfer process; the terms on which the recepient can carry out his own adaptation and R & D (or bring in inputs/technical assistance from local suppliers not approved by the foreign supplier. These and many other elements (discussed in the next two sections) are crucial aspects of the capability accumulation process - yet the literature of the 1970s gave little indication of the degree of importance which the recipient attached to achieving a favourable agreement on these issues. I would argue that even today many recipient firms would believe that the extra short-run financial costs likely to be associated (by the recipient paying a higher price) with gaining supplier acquiescence on these issues during negotiatons, would probably not be considered worth the long run returns to increased capability accumulation.

It is equally unlikely that the supplier would be willing to agree, for instance, to massive recipient participation in the engineering and design process unless it were sure of receiving an adequate return for the possible loss of these valuable assets. As a result, the supplier will probably give the highest priority to deflecting the recipients interest in acquiring particular types of technical knowledge by giving concessions (after much prolonged 'tactical' debate) on what it considered relatively non-essential elements. Alternatively, the situation may also exist where the supplier would in fact be willing to do more training, local design or process adaptation than it initially offers if the recipient applied the proper amount of persuasion. There is evidence to suggest that this is a common characteristic of many technology transfer negotiations (see, for instance, Junta 1976).

Unfortunately, as we noted in Lectures Five and Six, the recipient firm frequently fails to exploit these relatively easy opportunities to increase its access/accumulation of what may be quite important skills or areas of technical knowledge by failing to press home its advantage. Whether this failure is because the recipient was unaware of the chance for action during negotiations or because it simply lacked the motivation, the outcome is the same. Much of the 'dependence' of Third World firms on extensive and continuing imports of foreign technology is the result of the failure of these firms to exploit to the fullest extent possible, the opportunities available to them within the current structure of the international technology market.

This line of argument implies that effective action to use the bargaining process to increase the contribution of technology transfer to capability accumulation is possible at both the firm and the national level. The central problem appears to lie with the failure of the recipient to either be aware of or be willing to exploit the opportunities to increase its level of technical skill. However, there are a number of ways in which government intervention could provide considerable help during the negotiation process. For instance, some form of institutional mechanisms could be set up (or existing ones reoriented) to effectively ensure that technology contracts (and indeed all transactions submitted for approval) fully exploited the capability accumulation opportunities inherent in the project. This could be done through ex-post vetting (as with existing registries) or through direct support to the recipient during negotiations. This support could be through means of technical advice and/or financial subsidy to offset the higher costs involved in getting the supplier to allow access to certain categories or appropriated technical knowledge. There may, of course, be a conflict between the government's capability objectives, which might actualy increase short-run costs and its desire to reduce the price of the technology acquired abroad - but as will be discussed in Section 3, the conflict is likely to be more present in theory than in practice.

2. Terms and Conditions

We now move away from discussing the slightly amorphous characteristics of the bargaining process and concentrate instead on analysing the more concrete outcome of the process - the technology contract. Much of the available data and analyses which contributes to the discussions of price in the literature comes, in fact, from the examination of technology contracts which have already been agreed to and are currently in force. As we shall see, many of the biases and shortcomings in the discussions of the price issue reflect the inadequacies both of the evidence gleaned from the technology contracts and of the analytical treatment of this data. Nevertheless, as I shall also argue, the correct compilation and analysis of the informtion contained in contractual agreements can constitute an important guide to formulation of policies on technology, price and acquisition at the national level and for individual firms entering into their own negotiations. In this section I shall be examining the specific contents of technology contracts, while in the next section I discuss some of the salient analytical characteristics of these agreements.

The Technology Contract: What it is and what it is not

Despite the strong weight given in the literature to the technology contract, it is important to note that, although a good deal of the flow of technology between countries is covered by some form of technology contract, we really have little idea of just how large a share of the total this is. Moreover, in addition to those individual transfer events not covered by contracts, even when a contract does exist, a sizeable chunk of technology transfer probably occurs outside the terms of the agreement. In both cases, we have no way of knowing if the sample of contracts available for analysis is in fact representative of the total population of technology contracts and technology transfer events! Although the discussion that follows takes place within these parameters and even when we limit our attention to reviewing the available literature on technology contracts, we are nevertheless referring to a very wide variety of contractual agreements.

In general terms, a technology contract, by definition, is a 'memorandum of the agreement reched by the negotiating parties and a legal document binding each of the parties to the terms of the agreement for a specified period of time.'

Although this is adequate to define the universe of agreements that we are dealing with, it is difficult to operationlise this definition of a technology contract in any meaningful analytical sense. This is so because there is very rarely a case where a single contract covers all aspects of the transaction. A single contractual document may be used when a very narrowly specified element of technical knowledge is being supplied, such as an item of machinery, or the services of a specific individual. However, as one begins to move to transactions of greater scope and towards the more complex forms of transfer commonly covered by a license contract between supplier and recipient, the parties involved tend to conclude a number of fairly specifically defined agreements all of which relate to a single industrial project.

Although most transactions are covered by a multiplicity of agreements covering different phases or aspects of the transfer process, the literature does not usually make any distinctions between different agreements when examining the clauses these contain. Although these studies give the impression that the transactions under review are defined by a single document, there are some items in the literature which do specify the range of agreements involved. For instance, Kaplinsky (1976) analyses the contents of separate agreements defining the joint venture relationship between Anglo-American and the sambia Government. These are the Master Agreement, The Heads of Agreement, The Memorandum Articles of Association, The Management Contract, The Purchasing Contract and the Marketing Agreement. Another typical set of contractual agreements reviewed below contains a Master Agreement, Shareholders Agreement, a Supply and Construction Agreement (with 2 appendices) and a Management Consultapnt and Technical Services Agreement.

A close examination of the contents of the different agreements covering a transaction would reveal that, although they may seemingly relate to different aspects of the transfer, they may not be mutually exclusive with regard to specific issues they cover. It is quite common to find that, whereas the recipient may be given certain guarantees or rights in one agreement, these may be revoked or superceded in subsequent clauses or agreements. Consequently, any policy oriented review of contractual agreements must take account of the entire set of agreements referring to a specific transaction, since only by analysing all of these various agreements will it be possible to acquire a full picture of the terms and conditions governing the relationship between the two parties.

Functions of a Technology Contract

The central functions of a technology contract are to delineate the commitments of both supplier and recipient in relation to the specific transaction. At a general level, the commitments of the supplier are usually of two major types: Firstly, the contract stipulates that the supplier grants the recipient the legal right of access to the company owned or controlled technological assets as they are specified in the contract - i.e. know-how, patents, trademarks, equipment etc. Secondly, the supplier undertakes to furnish the requisite type and amount of information, technical assistance and other components or services necessary to fulfill any performance requirements, output targets or quality levels set out in the contract.

The commitments of the recipient can also be grouped under two headings. The recipient agrees to exploit or utilise the transferred rights, know-how or equipment in accordance with the terms of the contract. Correspondingly, the recipient must pay any agreed royalties and other remunerations to the supplier in accordance with the terms of the contract.

Contracts also perform an important legal function which can be crucial to the interests of both parties. This function is to precisely delineate the legal and other procedures to be followed in ameliorating any difficulties or conflicts that may rise between the two parties during the term of agreement. It is increasingly recognised that the clear specification of these procedures is vital where a Northern supplier and a Third World recipient are involved, particularly if the recipient is a public enterprise, because of the higher degree or risk of inherent conflict that might exist between the parties.

In addition to its legal and commercial function, the technology contract plays a much more fundamental role in defining the relationship that exists between supplier and recipient. In Lecture Three, I emphasised that one of the main characteristics of different transfer mechanisms was the degree of control exercised by the supplier over the transfer process and the recipient's productive activities. Establishing and maintaining control is crucial for the supplier to be able to meet its objectives in relation to the transaction. the technology contract is one of the devices used by the supplier to formalise control.

In general, the empirical and conceptual literature has recognised both the explicit commercial and legal characteristics as well as the more implicit control function of technology contracts. The contents of the contracts have tended to be divided into two groups which reflect this perception of the dual purpose of contractual agreements. The first group relates to all those clauses and aspects of a technology contract which have some impact on the total price of the transaction. The second group brings together the clauses which relate to restrictions imposed upon the recipient's use of the technology. These clauses, which are now commonly referred to as restrictive business practices, are assumed to be related to the efforts of the supplier to exercise control over the recipient.

Clearly these two groups of clauses are very closely related and frequently overlap, with a single clause affecting both the price of the technology and the control function. Moreover, their more or less simultaneous existence in a single contract is the result of the same set of contextual factors. However, for our purposes I prefer to discuss these issues separately. This is not because I do not recognise the interconnection, but rather that I feel that the literature (as well as policy maker and recipient firms) does not give sufficiently explicit attention to the issue of control, either with reference to the terms of contractual agreements or in relation to the entire transfer process. Therefore, in the discussion that follows, I will concentrate primarily on the price-related clauses in contractual agreements. I will deal explicitly with the issue of control in technology contracts in the next section.

It is important to note that since I will be concerned largely with the content of technology contracts, I will not be able to treat in any detail a number of factors which, in effect, define the form of the transfer process to which the contract relates. Among others, these factors may be: the type of transfer mechanism involved, the equity relationship between the supplier and recipient, the elements of transferred technical knowledge covered by the contract, or the nature of the bargaining process which precedes the conclusion of a contract. Clearly these variables and the relationship between them will influence the precise form that the technology contract may take. For the moment, however, I will be holding these factors constant, and will only introduce them into the discussion whenever necessary for purpose of clarification.

In preparing this section I have drawn fairly heavily upon the extensive literature in this area. The following area those items which have been used in detail, although where necessary I have referred the reader to the much more explicit treatment of items in the original source.

(a) Chapter IV of the UNCTAD Guidelines (1972). This discusses in general terms some of the analytical problems associated with the analysis of contractual agreements.

(b) A UNIDO document - 'Guidelines for the Acquisition of Foreign Technology with Special Reference to Licensing Agreements' (1978), which discusses in slightly more detail the various types of contractual clauses and their negative effects on the recipient. It is aimed at firms and host governments negotiating license agreements with foreign suppliers and is intended to assist them in avoiding the imposition of unfair contractual terms.

(c) A document published by the World Intellectual Property Organisation, called 'Licensing Guide for Developing Countries' 1980. The relevant section is a highly detailed treatment of the content of technology contracts (especially licensing agreements). It describes the function of each group of cluses and is very valuable because it gives detailed examples of many clauses.

(d) M.A. Odle (1986). This study has very strong dependencia orientation and is highly critical of current patterns of technology transfer in that area. It is valuable because it provides a detailed listing of restrictive business practices to which I will refer in my discussion.

(e) C. Vaitsos' book, Intercountry Income Distribution 1974, (Chapters IV and V). These chapters refer explicitly to the content and implication of the contractual agreements registered in the Andean Pact countries in the mid-late 1960s. Vaitsos is specifically concerned with transfers which take place through means of foreign investment.

3. Clauses Related to the Price of Technology

As noted above, one of the prime objectives of the supplier in concluding a technology contract is to ensure that it receives an acceptable price for the technology it provides. The supplier has open a number of channels through which it can extract payment from the recipient. In the literature these channels are usually divided into two categories: clauses that refer to direct costs, and those clauses which result in indirect costs to the recipient.

A. Direct Costs

Direct costs refer to those charges which are specifically identified in the contract as payments to be made to the supplier. These payments may take two general forms.

(i) Charges for the right to use patents, licenses, know-how and trademarks.

(ii) Charges for the supply of specific elements of technical knowledge that may be required by the recipient in the pre-investment, investment or operating stages.

Type (i) direct costs

Type (i) direct costs are usually of two kinds - recurrent payments and lump sum or one-off payments. Royalties are the most common form of recurrent payment used in technology contracts relating to the more complex forms of 'packaged' transactions.

The precise wording of royalty clauses will obviously differ from contract to contract depending on the situation. Below, a common wording is given, taken from a contract for a patent license.

> In consideration of the Patent License granted here-under by the Licensor to the Licensee, the Licensee agrees to pay to the Licensor during the term of this Licence or for the duration of this Patent, whichever is earlier, royalties in the amount of (figures)% of the net selling price of the Product manufactured and sold in the exclusive territory for manufacture and sale by the Licensees and sold or otherwise disposed of in the non-exclusive territory for sale to the extent to which, upon manufacture, the product includes an invention claimed by the Patents.

Royalty rates are usually fixed as a percentage of some base category specified in the agreement. The most common royalty base is on gross or net sales although other bases have been identified such as per unit of output/gross profit, value of imported components etc.

The royalty percentage rate tends to vary quite widely depending on the technology involved and, of course, the relative bargaining power of the two parties. Around 2-5% is assumed to be about average for contracts using gross sales as a royalty base. For contracts where the royalty base is linked to productivity or profitability (value-added), the rate tends to be somewhat higher, usualy around 10%. However, value-added is used as a base much less frequently than gross sales even though it is argued to be a more reasonable yard stick of the contribution of the technology to the recipient commercial activities.

By using gross sales as a base, the supplier's return is not tied in any sense to how efficiently or effectively the recipient uses the technology. The supplier is guaranteed a return as soon as the first unit of the commodity produced with the technology is sold. Obviously, from the recipient's point of view, using gross sales as a royalty base has a number of disadvantages. It makes no allowance for downward fluctuations in productivity (due to increases in costs, input prices etc.), yet penalises the recipient when sales go up. A value added royalty base, on the other hand, would give a much better idea of the contribution of the imported systems to recipient productivity. In this case, suppliers would possibly be more inclined to ensure a fuller, more effective transfer.

A number of governments have placed legal ceilings on the size of the royalty rate. Such limits, although necessary, probably do little to reduce the overall total returns to the supplier since, as we shall see below, he is able to increase the size of the payment under other headings which, in turn, maintains his overall rate of profit. More problematic, however, is the refusal of most suppliers to shift their royalty base away from gross sales towards value added. Since this is in the interest of both recipient (unless it is a WOS) and host government, it would appear to be a useful and relatively easy intervention to make. But there is little evidence that host Third World governments have taken advantage of this option.

Lump sum payments constitute the second form of payment under type (a) direct costs. These are simply outright financial payments by the recipient which are made all at once or spread out over a period of time. They may either replace royalties as the form of payment or be combined with royalty payments, so that a fixed sum, say $1m., is to be paid at the beginning of a project, with additional royalty to be paid annually thereafter. In this case, the lump sum payment may be viewed by the supplier as a payment for its past R & D or for disclosure of basic information. This combination of the two is very frequent and is usually employed for tax purposes.

The elements covered by the lump sum may be the same as those covered by royalties, i.e. right to use patents, trademarks, etc. Or else it may also be related to the use and/or purchase of specific elements, in which case it plays the same function as a fee. Usually, the items covered by a lump sum payment are specified in the contract, as well as the precise amount being paid for each element, as the following clause illustrates:

> In consideration of the grant of Industrial Property License, the supply of know-how and technical information and the provision of technical services, the Parties hereto agree on the amount of ---- consisting of the following:

(i)	Industrial Property License	-------
(ii)	Know-how	-------
(iii)	Technical Information	-------
(iv)	Technical Services and Assistance	-------
	TOTAL	-------

The use of lump sum payments may or may not have advantages for the parties involved. Frequently, as mentioned above, tax considerations are involved when different tax rates apply to the two categories of payment. It may be more convenient to use a lump sum payment when no continuing relationship between supplier and recipient is necessary - perhaps because the transferred element is simple, easy to assimilate or can be transferred all at once. For the recipient, it does have a minor advantage that payment obligations are fulfilled all at once avoiding the necessity of continual supervision of the payment flows.

However, the major criticism that has been advanced against lump sum payments is similar to that levelled against royalties based on sales. Both of these are, in effect, fixed costs which are not tied to any measure of productivity. In the case of a lump sum payment, the amount is often determined on the basis of some assumed level of performance. (Odle, 1979). As with royalties, additional clauses may be inserted in the contract that increase the amount of the payment. This frequently occurs when payments are spread out over time.

Type (ii) direct costs

The second category of direct costs relates to payments that may have to be made for specific services provided by the supplier of the technology. The literature divides these costs into three categories.

(a) training programmes for recipient's personnel.

(b) specific technical services performed by the supplier.

(c) use of expert personnel provided by the supplier during the period of the contract.

The conditions covering the supply of these facilities and services are usually specified in detail in the contract. The extent to which the recipient actually extracts from the supplier a commitment to provide the services subsumed under these three headings depends largely upon the bargaining power of the recipient during negotiations. Particularly in those contracts where the supplier's return is not tied to the efficiency of the recipient's use of the technology, a priori, the supplier really has little or no motivation to go to any extra expense under these headings. Where equity considerations, such as joint venture or wholly owned subsidiaries are involved, it is of course more likely that it will be in the supplier's interests to ensure that the recipient has access to all the factors necessary for commercial viability.

Whatever the equity position, it is in the supplier's interests to shift the larger part of the actual costs associated with these categories of activities onto the recipient. And, depending on the relative bargaining power of the two parties the supplier may also try to extract a monopoly rent for providing these services. It is unlikely that any exact figure will be agreed upon for these services and then entered into the contract. The usual situation is for the wording of the clause to imply that the supplier will estimate the value of the costs involved and stipulate when this is to be paid by the recipient. Even where a value is entered, provision for revision of the price is usually made in the contract. Pages 95-110 of UNIDO (1978) discuss in detail the various clauses relating to the various types of direct cost discussed above.

It is interesting and instructive to note that the relevant literature rarely discusses the implications of this particular set of clauses in any detail. In the Third World oriented discussions, they are primarily viewed as cost items that need to be considered in evaluating the total cost of the transaction - and as such should be reduced as much as possible during bargaining. The specific content of these clauses and their (non-price) technological implications for the recipient is given little attention. This bias presumably reflects the biases of both academic researchers and (probably slightly less so) those more directly involved with negotiating and implementing contracts.

I underline this lack of concern because, as I shall argue in Lectures Eight and Nine the activities carried out under these clauses (training and the provision of technical services) can be extremely important in determining that the recipient fully exploits the benefits of the transfer process. A wide range of elements of technical knowledge could be potentially acquired via these activities. Some of this information is likely to be quite crucial. Unfortunately, it is not at all clear that recipients or host government recognise the importance of these activities. The extent of their concern and the details of what takes place is frequently defined almost exclusively by the supplier during negotiations.

This activity could bear directly upon the technological capabilities of the supplier to support the 'core' technology that is being transferred. Obviously the supplier will be willing to allow access to the standard areas of operator training, and to provide (for a price) the amount and type of technical support required to fulfill the terms of the contract. However, these conduits, in fact could lead to more. Recipient firms could push for training to be extended to maintenanance, quality control, trouble shooting and possibly low level innovative activities. They could seek to have their own personnel much more extensively involved in the relocation and transformation activities that the supplier normally carries out. The provision of technical services could be organised to allow full participation of the recipient and the effective transfer of the expertise needed to carry out tasks usually performed (at recipient expense) by the supplier's personnel.

To achieve this objective, however, the recipient must first be able to specify the extent and nature of participation and must be prepared to negotiate very hard over these clauses. In many cases the recipient could gain a great deal more under these headings with relatively little effort and cost - more a case of missed opportunities (through willing acquiescence, ignorance or incompetence) rather than options blocked by supplier intransigence. Where recipient demands begin to impinge upon what the supplier considers essential to his quasi-monopoly, the negotiations will be difficult and the terms of access probably very much higher than might otherwise be the case. It is my contention that higher prices might well be justified because of the longer run benefit to recipient capability development - a position obviously in conflict with traditional concerns to give the Third World cheaper and freer access to technology.

B. Indirect Costs

This category of contractual costs covers a fairly wide variety of clauses in technology contracts which will have some effect on the overall price of the transaction. It also encompasses those aspects of contractual agreements which create operational conditions that result in costs to the recipient firm and to the economy which are not necessarily specified in the contract. These can be grouped under the following five headings: (i) costs associated with the operational characteristics of the contract itself; (ii) costs resulting from restrictions on the recipient's production and marketing activities; (iii) costs associated with the capitalisation of know-how by the supplier; (iv) costs associated with requirements that the recipient purchase intermediate inputs, raw materials, capital goods, etc. from a party or parties designated by the supplier; and (v) costs associated with profit repatriation.

(i) Costs associated with the functioning of the contract

Every contract will have a number of clauses which set out the terms on which the agreement is to be implemented. The cost element in these clauses in some cases may be quite explicit, yet in others the impact on the price of the technology is more subtle. These clauses relate to the following aspects of the contract:

(a) The duration of the agreement: the length of time which the contract is in force has a direct bearing on the size of the total payment stream. Suppliers and recipients may have conflicting objectives over this point; the supplier will wish to maintain the agreement as long as possible in order to maximise the revenue flow; however, it will be in the recipient's interest to limit the duration to the minimum period necessary to allow full assimilation of the technology. When the time period is restricted because of government regulation, the supplier may demand a higher royalty rate and/or lump sum payment in return for a shorter time period.

(b) The terms for renewal of the contract. Most observers recommend that renewal clauses should be included in order to allow access to new technology from the supplier. However, it has been found that in some cases these clauses require the recipient to pay additional royalties for technologies transferred in the previous agreement as well as any royalties for technology supplied during the subsequent period. If in fact there has been a significant change in conditions, then it is advisable to completely renegotiate a new contract, particularly if the recipient is in a stronger technological position.

(c) The terms of expiration or termination of the contract.

(d) Remedial mesures for specified types of default which involve direct charges for failure to meet or carry out the terms of the contract.

(e) External arbitration procedures in the case of conflicts not covered by (iv) above.

Groups (c), (d) and (e) clauses can all have financial implications for the recipient which need to be taken into account in evaluating the cost of the contract. Unless there are major disagreements during the life of the contract the additional costs associated with these clauses may be minimal. However, conflicts are quite frequent in contractual relationships between firms in the North South, particularly where the host government is directly involved. Given the contrasting objectives of the parties involved, it is widely argued that conflict is inherent in almost all technology transactions (Kaplinsky, 1976). As a result, it is perhaps best to be explicitly prepared to deal with these conflicts in an agreed-upon manner. Consequently, these clauses may be quite crucial since prolonged and contested arbitration of disputes can involve significant costs for all parties, in addition to those costs already enshrined in the contract. This is particularly true where early termination or nationalisation is involved, since the size and terms of the compensation agreement will obviously be influenced by the relative power of the parties in the arbitration process.

(ii) Costs resulting from restrictions on the recipient's production and marketing activities

The group of clauses and practices which fall under this heading form a significant category of indirect costs. In addition, they reinforce the supplier's control over the recipient and are partly intended to prevent the recipient from competing either with the supplier or with other recipients of the supplier's technology.

The bargaining process and the recipient's ability to resist the imposition of these clauses are a crucial determinant of the extent to which these clauses become part of the agreement. Most of the clauses reviewed below have been deemed restrictive business practices by UNCTAD on the grounds that 'no reasonable economic rationale can be found for their inclusion in a technology contract'. It is interesting to note, however, that suppliers are, in fact, able to offer quite excellent reasons to support their inclusion since they tend to protect the supplier's competitive position. The 'correctness' of either position is perhaps conceptually debatable, but in practice tends to be irrelevant. What does matter from a policy point of view is the extent to which the recipient or host government is able to organise itself to fend off the imposition of these clauses. The outcome, as we shall see, can be very heavily influenced by direct action on the part of recipient or the host government.

The specific wording of the clauses will differ quite widely so there is little point in describing each clause. Below we list the main groups of clauses and/or restrictions that come under this heading. These are taken from a variety of sources and are discussed in more detail in UNIDO, 1978; WIPO, 1980; and Odle, 1979.

(a) restrictions on the volume of production and the scope of the recipient's other (non contract related) production activities.

(b) restrictions on obtaining know-how, equipment and services from other suppliers for the manufacture of products which are deemed competitive by the supplier.

(c) designation of a territory or geographical area where products manufactured with the imported technology may be marketed.

(d) correspondingly, restrictions on exports either totally or limited to certain areas; requirements for the suppliers' approval of sales outside designated territory supplier.

(e) price fixing of final and intermediate products; requirement of supplier approval for prices; differential pricing schemes for products marketed in different territories, particularly those requiring higher prices for exported products.

(f) requirements for quality control practices which effectively limit output or else require recipient expenditure on technical services, testing procedures, etc.

(g) similar restrictions related to the recipient's use of trade marks and brand names.

(h) requirement of supplier's approval for recipient promotional and marketing schemes.

(i) clauses requiring the recipient to give exclusive sales or marketing rights (both domestic and export) to supplier or supplier designated outlets.

Indirect costs which result from the implementation of these clauses are of three types. The first type is constituted by expenditures by the recipient which are necessary to fulfill the requirements of the clause. These are relatively esy to identify and estimate and relate to (f), (g) and (h) above.

The second type of cost is primarily an opportunity cost and relates to the revenue foregone by the recipient as a result of limiting production, restricting its exports to areas designated by the supplier, and fixing the price of output. These opportunity costs are extremely difficult to estimate and relate to groups (a), (b), (c), (d), (e), (f), (g) and (i).

Finally, costs can result from clauses which impede the efficient use of the imported technology such as clauses (a), (f) and (h). These are, of course, closely related to opportunity costs and may result from the same clauses. For instance, a restriction which limits output levels may prevent the recipient from attaining potential economies of scale ((a), (f) and (h)). Price fixing and restricted exports can also cause a similar problem which results in fixed costs being spread over a less than optimal output base.

All of these indirect costs contain both a private and social element which need to be disentangled before any accurate assessment of total cost can be made. There is likely to be considerable divergence in objectives over this point between the host government and the recipient firm particularly if it is in the private sector.

(iii) Costs associated with the capitalisation of know-how by the supplier

A common characteristic of technology contracts is that the supplier may take part of its payment for technology in terms of an equity share of the recipient. This may occur both when recipient and supplier are independent and when some form of equity participation already exists.

In the latter case, capitalisation of know-how effectively increases the supplier's ownership share of the recipient without increasing the supplier's capital contribution, while in the former, it gives the supplier an equity participation with no capital contribution. This is a device frequently used as part of an acquisition strategy by a supplier trying to establish a gradual presence in a local market without undertaking the sizeable commitment required to set up a subsidiary. (Newfarmer, 1979). Alternatively, recipient firms frequently see it in their interests to exchange equity shares for technology in order to ensure that the supplier is fully committed to the transaction. Although this seems a rational strategy for a strong recipient, it may be disastrous for a weak firm. Such a recipient may be unable to exert countervailing pressure against supplier efforts to control its activities, or else may still fail to extract full benefit from the transaction because of fundamental technological inadequacies.

The effects of know-how capitalisation constitute an indirect cost to the recipient for the use of technology which may, in effect, already be paid for through royalties and fixed payments, and through profit remissions in the case of wholly owned subsidiaries and joint ventures. The costs associated with this practice will result from the following actions undertaken by the supplier. Those actions may frequently be explicitly included in the technology contract. (Vaitsos, 1974, discusses this point in more detail.)

(a) The supplier may stipulate the payment of dividend charges on equity shares granted by recipient as part of the capitalisation deal.

(b) Alternatively, the supplier may extend a loan to the recipient related to the alleged value of the technology, which may or may not be converted into equity at the end of a specified period. In this case, interest payments on this 'debt' constitute an indirect cost.

(c) Particularly in the case of WOS and JVs capitalisation may reduce tax payments by enhancing the capital base of the recipient company through capitalising intangible assets (know-how, technology etc.) and reducing the factor on which tax coefficients are estimated.

(d) Physical plant provided by the supplier may also be capitalised with effects similar to (c) above with one added benefit for the supplier. Frequently the tangible assets supplied may be machinery which has already been depreciated by the supplier in its home country and hence have an alternative value of nearly sero.

(iv) Indirect costs associated with repatriated profits

This category of costs relates to the situation where the supplier has a major equity share in the recipient firm, either as a wholly owned subsidiary or joint venture. This equity participation entitles the supplier to a share in the profits earned by the recipient. The remission of these profits to the parent may in part be adjudged as payment for technology. However, serious conceptual and analytical difficulties arise in connection with trying to ascertain which part of the profit flow relates to the technology transferred.

Foreign investors are commonly represented as providing a collection or 'package' of inputs of which technology is only one part. The parent firm's objective function is to maximise its total returns on the collection of factors of production which it supplies to all affiliates. Largely as a result of the intra-company nature of these resource flows, the parent company has open to it a number of channels of what Vaitsos calls 'effective profitability remission' through which it can arbitrarily repatriate profits. These channels are declared profits, direct technology charges such as royalties and lump sum fees, and indirect charges like those being discussed in this section, such as interest payments and transfer pricing. (Because of his specific concern with foreign investment, Vaitsos in fact treats these two indirect costs slightly differently and refers to them as separate channels of profit remission.) Consequently, the level or rate of declared profits, which were usually the main resource flow examined in conventional economic analyses of private foreign investment, may seriously understate the true effective profit rate. This has serious implications for government tax revenues since most governments assess taxes on declared, rather than effective, profits. In addition, given the arbitrariness with which the parent firm allocates resource flow between all remission channels, it is extremely difficult to identify what portion of total profits should be allocated as technology payments.

However, the level and extent of taxation is often a major point of contention in negotiations as foreign investors attempt to extract tax concessions from the host government as the 'price' for establishing production facilities. Hence, even where a technology contract does not exist between parent and subsidiary, there is frequently a tax agreement of some sort which sets out the terms agreed to between the parent firm and the host government. Where contracts do exist, taxation clauses are usually included. Given the often long term nature of technology contracts, the levels of tax which are established can have significant revenue implications for both supplier and host government. In general, Third World governments have been very lenient on the issue of tax on foreign corporations and as discussed above, have failed to fully exploit their bargaining leverage on this issue. As the typical sample clause shown below reveals, tax concessions are frequently very comprehensive.

> The Government shall: ensure that the Company shall be exempt, during the period in which the foreign long-term loans are outstanding, from paying or having imposed upon it any taxes, duties or levies, including but not limited to the following:
>
> 1. Income tax (corporate and personal)

2. Corporation tax

3. Property tax

4. Excise duty tax

5. Witholding tax

6. Surtax

7. Import tax, tariffs or duties (either during the construction and start-up phases of the COMPLEX or afterwards upon the imports of fuel and chemicals and spare parts)

8. Taxes provided for under the tax acts: and

9. Any other taxes or levies or impositions created either in Country A...under any existing or future laws with regard to the site, the CONCESSION AREA, THE COMPLEX, the equipment and machinery set forth in Appendix I of the Supply and Construction Agreement, the products of the complex, and any profit said to be derived from Y's (foreign firm) execution of its obligations under the Supply and Execution Agreement, and also the Company shall ensure that, if any such taxes, levies or impositions are paid by Y or the Company (JV), or if Y or the Company should purchase in Country A for use at the COMPLEX any goods or services which are burdoned with any such taxes, levies or impositions, the Government shall reimburse Y or the Company within thirty days of the despatch of an invoice from Y or the Company.

In short, the above joint venture project and the supplier involved are completely relieved of any tax burden whatsoever in connection with this particular transaction. If, as is often the case, such clauses are included in a contract which also contains restriction on the recipient's access to essential elements of the supplier's technical knowledge, then it is difficult to see exactly what type of benefits flow to the host economy from technology transactions. An interesting point to note is that taxation agreements negotiated with individual firms frequently contradict or counteract the objectives of national tax legislation. Tax laws are often administered by a different ministry or agency to the one involved in technology negotiation. These sorts of policy contradictions between different government agencies are very common and serve often to obstruct or negate efforts to implement a coherent national technology policy.

(v) Costs associated with the purchase of inputs from the supplier

Clauses requiring the recipient to purchase a whole range of inputs from the supplier are frequently found in contractual agreements involving the supply of more or less 'packaged' technology. As a result, a great deal of attention hs been given to the revenue effect of these tie-in clauses in the literature and in policy measures. The available evidence seems to indicate that payments received for tied purchases may represent a significant source of profit for suppliers, particularly where restrictions are imposed on the size of more conventional payments such as royalties and fees.

These 'tie-in' clauses may relate to the supply of equipment of all sorts, spare parts, intermediates and components, raw materials, technical services, personnel, etc. They take a number of different forms in the contracts depending upon factors such as the astuteness of the recipient and the existence (or not) or legislation prohibiting their inclusion. In some cases they may be quite explicit as the example below, related to intermediate product purchases, demonstrates:

> For the elaboration of product, covered by article No ... in the contract, the licensee is required to purchase all necessary products, (raw materials and intermediate products) as recommended by the licensor, from the source that the licensor indicates. (Vaitsos)

Usually these are backed up by clauses, mentioned above, which give the supplier the right to set prices for these intermediates which are 'agreeable' to the recipient.

Alternatively, the tie-in requirements may be stated more implicitly or subtly as the following clause relating to machinery purchases shows:

> The installation and any eventual modification or amplication of the licensee's plant will be subject to the approval of the licensor;...such purchases for (machinery) will be subject to the licensor's consent.

In this case, supplier consent or approval is required by the recipient. This, in effect, gives the supplier the right to determine where the recipient will get its machinery simply by rejecting all those of whom it does not 'approve'. The same effect can be achieved through restricting or prohibiting the use of local materials or suppliers.

Restrictive clauses relating to quality control, patents and trademarks are still another way of tying the recipient to the supplier for its component of raw materials requirement. This is done simply by requiring the recipient to demonstrate that all its inputs acquired from other sources are of sufficient quality to ensure a product of a sufficiently high standard to satisfy the supplier. If not, the supplier is given the right to ensure the availability of intermediates of the right standard.

Even without explicit tie-in clauses the technical requirements of the transferred process may, in effect, impose the same restriction. The supplier may schedule the transfer in such a way as to ensure dependence by the recipient, or else specify inputs which may be best suited to supply. This is frequently the case when, although alternative inputs might be usable, they may require minor alterations to the process or operating parameters. This would be ruled out by the process supplier to ensure the use of his inputs.

The cost element in these tie-in clauses has four components. Firstly, there are the opportunity costs involved in not being able to purchase inputs on the open market where they may be available at a more competitive price. When the required inputs are available locally, this then also implies an impact on local suppliers who are not given the opportunity to provide inputs to the local recipient. In this case, the opportunity costs involved may be considerably more significant since these restrictions affect local capability development.

Secondly, the supplier may succeed in negotiating a release or reduction in the rate of tariff that applies to imported inputs. Tariffs, like the revenue taxes discussed above, are important sources of revenue and of control over foreign exchange flows and their reduction or elimination may impose additional costs of a sizeable nature.

Thirdly, the supplier is able to create a monopolistic position vis-a-vis the recipient partly by specifying required inputs and partly by imposing tie-in requirements. This allows the supplier to 'over price' the inputs he provides well above their price on a competitive market. The degree of monopoly rent which the supplier can capture depends upon the strength of his quasi-monopoly - which in this case is very strongly determined by the recipient awareness of prices of alternatives and as well as its bargaining ability.

The extent of over-pricing tends to vary quite considerably between sectors and even between products. Likewise, the size of overpricing also varies, with figures ranging from 5% to as high as 500% above the market price, being reported in the literature. There is evidence that the importation of intermediates, including capital goods, tends to rise as a percentage of the total import bill as import substitution proceeds. Because of the great diversity of the input requirements of many final stage assembly and processing industries, the potential for overpricing is considerable. The most well documented sector where overpricing has been shown to occur is the pharmaceutical sector where intermediates often account for up to 80% of the total materials import bill. (See Vaitsos, Ch. IV). Although it is unlikely that these levels are maintained in other sectors nevertheless, the loss of tax revenue resulting from overpricing could conceivably be quite substantial.

The problem of overpricing relates directly to the final component of indirect costs which may occur under this category of clauses, and which differs significantly from the other costs that we have been discussing. These are costs which result from the transfer pricing of commodities, which are traded internationally by firms which have affiliates, joint ventures or wholly owned subsidiaries in a number of countries. Where equity relationship exists, the requirement that recipients acquire these commodities from the supplier is determined not by contractual tie-in clauses but because the recipient is under full control of the supplier. Contractual clauses to this effect may, of course, exist in the case of a parent-subsidiary transaction and there is some evidence (Helleiner, 1973) that transfer pricing may take place between independent firms through mutual agreement. However, the essential problem is that the price of the transaction is not affected by the operation of market forces.

Below, Sanjaya Lall sets out the differences between trade in intermediates that takes place between independent firms as opposed to that which occurs between firms with an equity relationship.

> The fact that a transaction involving transfer or sale of goods takes place within a firm, regardless of whether or not the firm spans different countries, and the firm is free within broad limits to assign whatever price it likes to those goods, means that the traditional theory of pricing in competitive, oligopolistic or monopolistic markets ceases to apply to the process of transfer pricing. The essential difference is simply that in transactions on the open market or between unrelated firms, the buyers and sellers are trying to maximise their profits at each other's expense, while in an intra-firm transaction the price is merely an accounting device and the two parties are trying to maximise joint profits. It is possible that the accounting price may approximate the arm's length price of the goods (the price which would obtain in an open-market, or in a transaction between unrelated parties), but certainly there is no presumption that this should be so: any other price is equally plausible, and the conditions mentioned below will determine whether the actual transfer price will deviate from the arm's length price. (Lall, 1973)

In fairly simple terms, if suppliers are able to manipulate transfer prices in this fashion, then by structuring their profit and loss accounts they can show much lower rates of profits than may really be the case. In turn, this means that the revenue base, and hence tax revenues, are greatly reduced. Transfer pricing is an extremely important channel of profit remission within international firms since it creates the opportunity for large implicit income flows which are much more difficult to detect and tax than the explicit income flows of royalties, fees, declared profits, etc.

The avilable evidence suggests that transfer pricing poses very sizeable policy problems for all country governments, not just Third World nations. There is already an extensive literature on the subject and a number of conferences have been convened to try to determine ways of establishing if these practices are used, in which sectors, in which countries and, if so, how they should be controlled. Clearly, it is an issue which also extends well beyond its relationship to tied clauses in technology contracts.

4. Technology Contracts and Control by Suppliers

In the introduction to this lecture, I argued that contractual agreements serve a crucial function in helping to formalise the control that is exercised by the supplier over the transfer process proper and over the activities of the recipient. At a fairly general level, we can identify two broad objectives of the supplier in establishing and maintaining control through contractual agreements. The first objective is to maximise its profits from the transactions within a given set of constraints. I have already discussed how contractual agreements are used to achieve this objective.

The supplier's second objective in maintaining control relates to the necessity to protect its quasi-monopolistic position in the technology market. (Cooper and Hoffman, 1981). By providing recipient firm with access to its monopolised assets (particularly technology but also trademarks, patents etc.), the supplier may be creating a potential competitor. If the recipient were able to use the transferred technology to develop its own capabilities, it could conceivably, after a period of time, function independently of the supplier in the same markets. This could lead to a reduction in the market share and hence the rate of profit of the original supplier. Suppliers usually explicitly recognise that this potential exists and consequently will try to prevent or obstruct the efforts of the recipient to develop its own indigenous capabilities.

At a fairly general level, we have already argued that this type of reasoning underlies the concept of license agreements which gives the recipient only temporary access to the supplier's technology instead of outright ownership. Moreover, this is also one of the reasons why, as was discussed in Lecture Three, the supplier tries to organise the transfer process so that it does not provide the recipient with the technical knowledge which gives rise to its monopolised assets.

More specifically, the supplier will use the contractual agreement to achieve this second objective in a number of ways. Firstly, by specifying what is actually provided to the recipient. Secondly, by giving itself control over certain crucial decision-making functions of the recipient. Thirdly, by minimising its risk and ensuring control of the outcome of conflict. Fourthly, by restricting the ability of the recipient to undertake and appropriate any innovation or adaptation on the imported technology. Fifthly, by restricting the possibility of the firm continuing in the market as a competitor after the agreement has expired or diffusing the technology to other firms. The set of clauses which I will be examining below will obviously also have an impact on the 'price' of the technology, in addition to those discussed in Section 3. However, they are likely to have a far greater effect on the longer term development of the technological capbilities of the recipient firm, which is the area where I wish to focus my comments.

A. Specification of the Technology to be Transferred and the Responsibiities of the Supplier

In Lecture Three, I introduced the notion of packaging and the various ways in which the supplier may combine various productive factors within a single transaction. For this reason, from a research point of view the contractual agreements which set out what elements and services the supplier will provide can be a very useful information source on what the recipient is obtaining under the agreement.

The degree to which the elements to be supplied are actually spelled out in detail will vary depending on the contract and the outcome of the bargaining process. In the agreement reviewed below, it is specified that the seller shall carry out nearly every activity associated with the transfer including construction of plant, selection of equipment and all design and engineering activities such as:

1. Structural and civil engineering, and the preparation of bills of materials for all structural items.
2. General and detailed flow sheets.
3. Specification for all machinery, piping, electrical equipment and materials.
4. Selection of machinery and equipment.
5. Technical data for erection of machinery.
6. Layout drawings of the mills and of each department.
7. Detailed drawings for piping and electric wiring.

This degree of packaging clearly has implications for the price of the transaction (as discussed above). However, it also means that the recipient plays no role at all in crucial technological activities which, in this case are the source of the supplier's quasi-monopoly - i.e. engineering and the specification and selection of equipment for this particular productive activity.

Up until the early 1980's most of the existing studies of contractual agreements had not examined in any detail the actual elements of technical knowledge which are covered by the contract. As the above example demonstrates, some contracts do, in fact, list the transferred elements. Depending on the detail supplied, it may be possible to determine where the recipient actually acquires technical knowledge and where it is simply the passive receiver of artifacts produced by the supplier, such as engineering specification, plant layout drawings, etc.

It is in the supplier's interest to provide the recipient with access only to limited bits of know-how, which do not present a threat to its quasi-monopoly, such as that offered in training programmes which provide recipient personnel with operational and possibly maintenance know-how. Several recent studies of contractual agreements have shown that

> Licensing agreements (in Jamaica and the rest of the Caribbean) provide (local) producers with access to the most simple and unimportant elements of technology. Basically, the contracts make allowance for their use of the specifications, formulae, problem-solving and promotional assistance of licensors. However, in no instances do we see provision made for the licensee to acquire a design capability, to conduct or participate in product and process innovation, or to be exposed to technology of a sort that could possibly promote their technological development over time. (Odle and Arthur, 1984, p. 42)

There is some limited evidence that recipients are occasionally able to ensure that the transfer of technical knowledge takes place at all levels - the Lockheed - case study by Hall and Johnson (1974) is a case in point. (Reviewed in detail in Lecture Nine). However, this type of situation, especially for Third World firms, is the exception rather than the rule, and these firms rarely seem to exploit the full learning potential of the transfer process, either because they choose not to or because of their weak bargaining position.

This aspect of the contract also relates to any guarantee clauses in the agreement. The nature of supplier's guarantees can be quite important to the recipient. These require that all technology and inputs will be of a certain standard, will be capable of achieving a specified level of production, and that all inputs, drawing, specifications, etc. will be supplied within a certain time period. In the case of the supplier failing to meet any of the conditions laid down, guarantee clauses will usually detail arbitration procedures and the terms of any penalties. In some cases, these clauses may be important, particularly if complex or 'leading edge' technologies are involved on which the supplier may wish to strictly control access to the technology after the deal has been concluded. Hence, a loose or vague specification of what is to be provided with costs to be 'determined in due course' will allow the supplier considerable freedom to manoeuvre the pace and form of the transfer to meet changing conditions that affect his profitability.

B. Exercise of Control over Decision Making within the Recipient

Depending on the nature of its quasi-monopoly, the supplying firm may seek to control certain strategic management functions carried out by the recipient company. This may be accomplished in a number of ways that may or may not require contractual agreements. The most obvious case where contracts are not necessary is where the recipient is a wholly owned subsidiary. However, contractual agreements are also frequently used to pre-empt management functions in the areas of finance, capital expenditure, marketing, purchasing, R & D, etc. This may be achieved implicitly through clauses which require supplier approval of certain actions.

We have already discussed some of these clauses in relation to purchasing of inputs, pricing, quality control, etc. Although restrictions on these activities may have an effect on the overall price of the transaction, they are also individual levers of control which, when added together, may give the supplier effective control of significant areas of recipient activity. Kaplinsky discusses another form of implicit control exercised in the joint venture between Anglo-American and the sambian Government. (Kaplinsky, 1976).

In addition to these implicit means of gaining control over management activities, frequently, the supplier may be given explicit responsibility for running the recipient production activities utilising the transferred technology. This is most commonly done by means of some form of management contract, which may or may not be part of some wider set of agreements. Likewise, the foreign firms which actually undertakes the management function, may or may not be the original supplier of the technology. One common arrangement is for a technology supplier to establish a separate management company which will undertake management contracts both for recipients of the parent's technology as well as for other firms.

The contractual agreement will usually contain specific clauses detailing the management functions to be undertaken by the supplier. These may give the supplier outright responsibility or else be couched in terms which require the recipient to take decisions only after consultation with suppliers, or 'after receiving the supplier's approval'. In addition to the function already mentioned in the discussion on indirect costs (d), other clauses giving the supplier control over the following activities have been identified. (Odle, 1978). The management company is given the responsibility to:

(a) supervise design, engineering, purchasing and construction.

(b) establish and enforce schedules, cost controls, accounting and reporting systems.

(c) authorise expansion of capacity and requisite materials purchases.

(d) purchase and sell capital assets.

(e) organise insurance over operations.

Where management is undertaken by supplier it may be on a day-to-day basis, or on the basis of frequent but regular intervals. This will depend in part on the nature of the production activities, with more complex continuous process industries such as mining or chemical production, requiring day-to-day supervision. More standardised methods of production may need only frequent checks on quality control and materials handling, and this stipulation may or may not be specified in the contract. The crucial aspect of this situation, which may be formalised in the contractual agreement, is that the supplier is usurping the recipient's management function and in so doing may be preventing the development of critically important skills.

C. Risk Minimisation

As we have noted, one of the supplier's overall objectives is to exert control and thereby reduce the threat to its quasi-monopoly. In addition to those means already discussed, the literature recognises that there is a set of clauses explicity designed to legally minimise the risk of the supplier in entering into the agreement. These clauses relate to the following issues:

(i) Exclusivity (or non-exclusivity) - under an exclusivity clause, the supplier may not provide the technology to other firms (or use it himself) within the designated area given to the recipient. Usually, the supplier will prefer non-exclusivity because this will not unduly restrict the scope of his operations. On the other hand, the recipient's interests are best served by an exclusive right to exploit the technology.

(ii) Assignability - these clauses cover the right of the recipient to assign the right to use the technology if the ownership of the recipient changes. The supplier may seek the right to rescind the agreement if ownership changes - particularly if the new owner is technologically more dynamic than the initial recipient. The existence of these restrictions is a serious constraint on the actions of the recipient and can have a serious impact on the diffusion of the technology through the economy. (Arthur, 1978)

(iii) Indemnification - a common provision in contracts is that each party agrees to reimburse the other for any legal damages which may result from being involved in the contract. Although this clause should relate to both parties, frequently only the supplier is indemnified against damages.

(iv) Force Majeure - this clause protects the parties from claiming for defaults in the event of circumstances which are not under their control. This provision is not usually found in contracts. This lack may have serious consequences for the recipient required to pay minimum royalties in all circumstances, even if outside events force a reduction or a halt in operation. Equally, the clause may also be specified so as to allow the supplier to evade responsibilities for delays in providing inputs which may really be under his control.

(v) Arbitration - perhaps the most important issue covered under this heading relates to the terms and process of arbitration to be followed in any dispute. Every contract agreement should have a detailed specification of the procedures to be followed. Frequently, the supplier will insist that the disputes should be settled in the courts of the supplier's home country and be adjudicated under the laws of the supplier's home country. Alternatively, there may be a provision for recourse to an international body such as the International Chamber of Commerce. The specification of these clauses has often been found to be biassed strongly in favour of the supplier (Odle, 1979; Kaplinsky, 1976).

These may relate either to disputes which occur during the life of the agreement, or to issues that may rise at the termination of the agreement. As mentioned before, termination clauses may include provisions which can be quite expensive to the recipient, or to the host government where nationalisation occurs (Kaplinsky, 1976), and which allow the supplier a large measure of freedom to terminate the agreement without showing 'due cause'.

D. Restrictions on Adaptation and Innovation by the Recipient

A number of clauses have been identified which appear to be designed specifically to impinge upon the recipient's innovative activities. As discussed above, these restrictions are a crucial part of the strategy of the supplier to protect its quasi-monopoly. Below, I draw on the work of Odle, (1979); to discuss the form of those clauses which relate to the following issues:

(i) Recipient improvements to the imported technology. Recipient efforts to improve or adapt the technology may be explicitly forbidden. More frequently, functions such as R & D, quality control, trouble shooting, major maintenance, may be carried out by the supplier for any innovative activities, as the two examples below demonstrate:

> During manufacture the (recipient) agrees to follow the drawings submitted by the licensor, and will not be allowed to deviate from them without his consent.
>
> The (recipient) is committed not to modify or improve the said (product), nor the machines using it, without a written authorisation for this procedure from the (supplier).

(ii) Access to externally generated improvements to the technology. As mentioned previously, the recipient may be restricted from gaining access to other technology suppliers either locally or abroad. In relation to any improvements the supplier might make, the evidence is contradictory. In some cases, the recipient is denied access to any improvements - either explicitly or else simpy by the supplier omitting to inform him. New innovations may have to be covered by a completely new agreement. These clauses explicitly restrict recipient's access to supplier's improvements.

> The firm granting the license is not obliged to divulge to the licensee plans of the parts or sub-assemblies that he (the licensor) will himself assemble or buy within his own country.

Another restriction limits actual manufacture:

> The (licensee) is committed to using the licensor's drawings or other documents once only, i.e. he can only make one piece or the corresponding part indicated on the drawing for each design and will not be able to manufacture or re-use other equipment or machinery which derives wholly or partly from (the licensor's) designs. Should extra items be needed, a new special agreement will be drawn up.

On the other side, however, there will obviously be cases where the supplier may be willing to provide recipient with new innovtions, e.g., where the recipient is owned by the supplier, or where the rate of return to the supplier will improve if the recipient can use the new innovation to attain a greater share of the local market. In either case, depending on the related requirements, this may inhibit the recipient's efforts to undertake any innovative activities.

(iii) Rights of ownership of local innovations. Despite imposing restriction on innovative activities, the supplier will recognise that improvements will frequently be made by the recipient. Consequently, the supplier will attempt to appropriate the recipient's innovations, as these clauses detail:

> The grantees of the license will hold an exclusive, divisible, and continual licence covering all improvements, patented by the licensee. This license may be used for the licensor's profit, both in his territory and in the rest of the world.
>
> In the case of a patent registered by the (recipient), the (supplier) will have the advantage of a free license of exploitation exclusively, and will be able to grant sub-licenses freely to its subsidiaries.

Corresponding to these clauses usurping the recipient's right to own its own innovation, the supplier may also attempt to oblige the recipient to pay royalties on any increased profit it gains as a result of its innovation:

> If the national firm modifies the (product), increasing its value, the licensor will be able to demand a reasonable increase in royalties for (the product) where this modification occurs.

E. Restrictions on Diffusion

Suppliers' efforts to restrict diffusion of its technology are directed at two possibilities. The first relates to the ability of the recipient to become a competitor after the expiration of the agreement and the second refers to the spread of the technology to other firms.

(i) Restrictions on the recipient after expiration of the agreement. This is the essential characteristic of most contractual agreements as it implies that the recipient has no ownership rights over the technology.

> The (recipient) is granted no property rights, as the rights are only licensed and cease when the agreement ends.

The practical implication of this requirement is that the recipient is supposed to return to the supplier the technology covered by the agreement immeditely after its expiration. Frequently, the recipient may also have to return any equipment originally provided by the supplier if the technology is embodied in the machines. There may be explicit clauses to that effect.

> The (recipient) will not be able to use the machinery when the patent expires. (The licensor) will be able to buy it at the end of the agreement under the following conditions:
>
> If the patent expires within a year: at the price at which it was bought;
>
> If the patent expires in the 2nd year: at 25% less than the price at which it was bought;
>
> If the patient expires in the 3rd year: at 40% less than the price at which it was bought;
>
> If the patient expires in the 4th year: at 70% less than the price at which it was bought;

> If the patent expires after 4th year: at no cost at all.

There may also be restrictions placed on the recipient acquiring other technology to compete in the same market. For instance:

> The national party to the agreement will not be able to devote himself to the same activity nor one competing with (the licensor) for 10 years after the contract has terminated.
>
> (The licensee) is committed to refrain from manufacturing or selling (the product) after the contract is rescinded. If he breaks this agreement, for each (product) sold he must pay US$20,000 (to the licensor).

These types of restriction, which are frequently found in contractual agreements, clearly may have a severe effect on the recipient's desire to undertake any innovative activities. Moreover, faced with requirements to give back the technology and stay out of the market, the recipient will be under a strong inducement to continue the contractual agreement.

(ii) Restriction on the spread of the technology to other firms. Most contracts will have clauses which require secrecy or confidentiality on the part of the recipient. These clauses frequently extend the secrecy requirement beyond the life of the agreement. Moreover, there may also be restrictions on sub-licensing by the recipient to other local firms.

There may also be clauses which attempt to limit the spread of the technology either between individuals in the recipient firm, or else by attempting to prevent the movement of staff to other firms. Even individual staff may be required to sign secrecy agreements of this sort.

> [The local firm] must use all the means at its disposal to prevent its staff from entering the service of another company making the products licensed, for five years after termination of the contract.
>
> Confidential information will only be accessible to those employees whose work requires their knowing it, and (the licensee) must be sure that they do not reveal it to unauthorised third parties.

The function of five groups of clauses discussed above would seem to be explicitly aimed at reducing or limiting the ability of the recipient to engage in innovative activities. While 'on paper', these clauses clearly have a potential negative effect, they are aimed at suppressing a process that is inherently difficult to identify, let alone control. Particularly where the recipient form is relatively independent of the supplier, it would appear to be almost impossible for a 'contract' to prevent a limited accumulation of capabilities at least during the post-transfer productive operations. Much more crucial to this is the ability or willingness of the recipient to get the learning process underway - a set of issues to which we shall turn our attention in the final two lectures.

LECTURE EIGHT

THE INVESTMENT PHASE OF TECHNOLOGY TRANSFER: CONCEPTS AND OVERVIEW

Introduction

The next two lectures concentrate on what I have termed the "investment phase" of the technology transfer process. This phase of the transfer process lies at the heart of my concern with the development of technological capacity and my intention is to disaggregate the activities and processes that occur during this phrase in order to lay open the mechanisms by which capacity accumulation can be facilitated through conscious and explicit intervention either on the part of the firm or the government.

In Lecture Eight I shall present a brief conceptual overview of the investment phase that identifies its major characteristics. In Lecture Nine I shall review empirical case study material which examines the experiences of developing countries in this phase of the transfer process.

1. Technological Transformation in the Investment Phase

The investment phase of the transfer process obviously involves a complex and interrelated series of activities which take place over a considerable period of time. In terms of placing boundaries around the set of activities involved, the opening boundary would be at the point when the supplier and the technique have been selected and the contract has been negotiated and agreed. The closing boundary would be located after the plant has been commissioned and the start up period is completed. I must stress that these boundaries are for analytical and presentational convenience and in no way should be considered as fixed or immovable points as either boundary can be shifted backward or forward.

The central feature of the investment phase is that it encompasses the progressive transformation of technical knowledge into techniques - the mixture of physical artifacts, human skills and experience which constitute a functioning production facility - plant; capital goods; a skilled labour force; operating procedures; input, process and output specifications, organisational and managerial structures, etc. etc.

The economist W E G Salter in his book, Innovation and Technical Change (1969) provides a useful description of the type of "transformation" process I have in mind:

> At any one time, there exists a body of knowledge relating known technical facts and relationships between them. This knowledge is at a number of levels which differ in their proximity to production. At one level is the knowledge dealing with basic principles of physical phenomena: the properties of fluid, the laws of motion, the principles of metallurgy and, in general, the

> area of knowledge we associate with pure science. At another level is the knowledge concerned with the application of these principles to production, the field of the applied sciences. Knowledge of this character bridges the gap between principles and practice, such as the transition from the formulae of organic chemistry to the design of an oil refinery, ... consider the various steps in the transition from a fund of such knowledge to techniques of production. Knowledge is in the form of technical facts and the relationships between them: the properties of steels and alloys, the means of transforming one type of motion into another, the thermal content of different fuels, and so on. Engineers and applied scientists have the task of translating such knowledge, some of it old and some of it new, into feasible techniques of production. (p. 13).

I believe that Salter's comments convey the notion of transformation quite well. However the technological transformation which occurs during the investment phase in fact covers a good deal more than Salter's "translation" process. It goes beyond the simple definition of feasible production techniques (ie production of the specifications for an industrial facility), and incorporates the activities which are involved in further transforming specifications into the concrete realities of physical plant and equipment and a fully operational production system.

One can obviously break down this transformation process in a large number of different ways.[1] Salter, for example, refers to "three stages in the transition from a fund of knowledge to techniques of production." On the other hand, engineers and managers who are directly concerned with investment products will usually disaggregate the technological activity involved into a very much larger number of discrete steps and stages.*

For the purposes of our discussion I would like to borrow from the analysis of Bell (1982) and Bell and Hoffman (1981) and propose a relatively simple three fold categorisation of the different stages in this transformation process:

(i) The first stage will involve various kinds of design and engineering activity. The output from this stage will consist of a set of detailed specifictions which define very tightly the characteristics of the production system which is to be created. In effect, the initial outline specifications which emerged from the feasibility studies carried out in the pre-investment phase will be transformed into a very elaborate description of the specific new facility. This description will define in precise detail the characteristics of the plant itself and all its components, the product, its inputs, and its operating procedures etc.

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[1] Cortes (1976) identifies seven "stages" of technological activity that are required for investment in petrochemical plants. For other examples of this sort see Kamenetsky (1979), Junta (1976), and Teece (1977).

(ii) Some of the specifications emerging from the design and engineering stage will usually have to pass through a further stage of transformation before they constitute real productive assets. Various kinds of capital goods production will therefore be needed to transform the specifications of the hardware components of the system into the realities of machinery, equipment, buildings, and related infrastructure. Some of these component elements of the production facility will be produced as standard items, while others will be specially built for the particular facility.

(iii) A final stage will involve assembling the various components of the system into a functioning operational facility. This will include on-site installation, testing, commissioning and start-up. It will also usually include various kinds of training in order to embody in operating personnel the skills, knowledge and expertise required to run the facility according to specifications. The output of this stage will consist of an operational, integrated production facility.

This three-step disaggregation is highly simplified, and what have been described above as discrete stages will usually in practice overlap with each other in different ways.

Implicit in this description of the transformation process is the concept already introduced in Lecture Two, that firms carrying out transformation activities draw upon their stocks of technological resources in order to provide the flow of technological imputs which are ultimately combined into a finished production faciltiy. As we shall see, the problem faced by recipient firms of countries is how to get supplier firms, who possess stocks of technological resources, to actually transfer these stocks of knowledge to the recipient. Nevertheless, the central point of the above is that the end result of such a process is a functioning production system that incorporated physical equipment imput and production systems operating procedures and the knowledge and skills embodied in the managerial and technical personnel responsible for operating (human-embodied technology) in the system.

And as Bell (1982) points out, what is involved in the process of creating such a system is "the progressive transformation of technical knowledge. At the start of the process (and at intermediate stages) technical knowledge in a disembodied form is drawn upon. This is usually knowledge which is generaly applicable to a wide range of particular production systems. Elements from this body of knowledge are selected and then made increasingly specific and detailed, while being progressively embodied in particular components of the final facility, which includes a specific set of technical information on its equipment, specifications, procedures, routines and people."

2. The Role of Decision-Making in the Investment Phase

Running alongside the transformation process, there is also an ongoing and obviously important stream of decision making that occurs during the investment phase. These decision making activities are somewhat distinct from the more specifically technological activities described above. The same three-fold categorisation of the decision making process that I introduced in Lecture Five is applicable here.

Decisions need first to be taken regarding specifying the terms of reference for the particular transformation activity. Here the most important set of concerns from our perspective is to set the terms of reference so as to obtain the maximum degree of local content or local supply of specific items or services. Even if the general co-operation of suppliers in unbundling various bits of the technology has been agreed upon in general terms, there still remains the problem of specifying precisely what it is that suppliers should do and what local suppliers should do. If detailed specifications of this procedure are not laid down then it may not happen. A similar point applies to the training elements that may be involved in, say, the commissioning and start-up stage - if the details of training - how many people, in what areas, for how long - are not set then the inevitable pressures placed upon contractors to reduce costs and speed up the process may mean that the training carried out may not be up to the standards agreed upon. The reason why these points are important will come out very clearly when I review empirical studies in the second part of this lecture. Similarly the identification of the agents to carry out the transformation tasks is equally important. Even after the broad details of the agreement with suppliers have been nailed down, there will inevitably be a wide range of tasks for which agents need to be identified and instructed. Depending on the degree of unbundling agreed to with the suppliers of the core technology, a good deal of responsibility for organ ising the supply of particular components should fall to those with overall responsibility for the project. Important opportunities for learning could be missed if proper attention is not paid to this type of decision-making.

Finally, the monitoring and evaluation function also becomes particularly important during the investment phase. The cost of correcting mistakes in design being allowed through into implementation is likely to be much higher once the project moves into its investment phase than if they are caught during the pre-investment phase, where the output is primarily paper based and relatively easily correctable. Once an improperly designed facility is in place, or the plant is supplied with incorrectly specified inputs, the costs involved in putting these problems right can be enormous. Along similar lines, opportunities for training which, even though specified, are not properly exploited during the investment phase, will not arise again and cannot be corrected. Such missed training possibilities have an inordinately high opportunity cost and could also conceivably have substantial negative effects subsequently when operators, maintenance men or quality control technicians make mistakes which would not have happened had they been trained properly. Finally an effective capacity for monitoring and evaluating ongoing transformation activities is essential to ensure that objectives specified in the terms of reference are fulfilled as expected.

All of three sets of decision-making activities must be performed in some way during each of the stages of technology transformation which occur during the investment phase. As mentioned earlier, they constitute a parallel stream of tasks that will inevitably be tightly interrelated with each other and with the technological task. This stream of decision-making activity will usually be critically important in determining the nature of the transformation process, hence the nature of its ultimate consequences for the user of the final system and for the economy within which that system is located.

Before moving on, there is one important difference between the decision-making functions in the pre-investment versus the investment phase that should be noted. In the latter phase, the decision-making process moves from being a set of activities that can, if necessary, be carried out or located in government ministries or groups removed from the actual project itself (in the case of pre-investment activities) into much stronger line management functions that require day-to-day involvement in the project. Because of the greater emphasis on the managerial dimensions of decision-making during the investment phase, I shall be using the term techno-managerial to refer to the overall set of activities involved in controlling the investment phase - as opposed to the technology transform ation services involved in producing the physical production artifacts.

3. Different Types of Technological Capacity and the Mechanisms for their Transfer

When one looks back over the historical experience of the developing countries in relation to the investment phase of technology transfer from North to South one feature stands out. Most of the transformation activities described above have taken place within supplier firms based in the advanced economies. Moreover even though the ultimate destination of the output of this transofmration process i.e. the operating production facility is a developing country, all or most of the decisions relating to the investment phase are also taken or controlled by firms (often the same firms) who are also based in the North. In putting it another way, the recipient enterprise in the South primarily receives the output of the different stages of transformation - in effect Type A flows - such as machines, operating manuals, formulae, etc.

There is no need yet to go into detail about the reasons why this pattern occurs - there are both internal and external constraints at work which we shall discuss at greater length in the next lecture. Whatever reasons there are for this biased distribution in the transformation process, the general policy problem it poses is how to get a greater share of the transformation activities in the investment stage to take place locally. This implies finding mechanisms that maximise the flow of Type B resources.

It also raises the related question of what categories of Type B capabilities should be acquired by recipient firms as a result of the investment project. The answer to the first question requires an assessment of the relative importance of different types of technological capacity. This is an important issue to the local firm and the economy but one which rarely ever gets discussed or researched in the mainstream technology transfer literature. Yet clearly if a firm or country recognises the importance of upgrading its stocks of technological capacity, it requires some guidelines as to which categories are most important, so as to ensure the cost-effective allocation of resources to their acquisition.

Unfortunately the information available to answer such questions is severely limited, and it seldom identifies in adequate detail the different sets of tasks and resources involved. Many studies, of course, have asserted that for instance engineering and design skills are crucial in the transfer process - Kamenetsky (1979) for instance. However, only very few have ever defined the precise quality or quantity of these skills that need to be acquired. What little information there is available does not allow any generalisations to be made which might be useful for policy purposes. Even less common is any attempt to separately identify the techno-managerial tasks involved in transfer, and to assess the nature of the resources required to carry these out.

Nevertheless there is some limited information available which we can use to build up a general picture of the relative importance of different types of skills associated with technological transformation in the investment phase associated with different types of activities. For example Table I below presents information on the costs associated with different types of transformation activity undertaken in the course of investment projects carried out in the advanced developing economies of Latin America, Asia and Africa. In all cases they involved international "technology transfer" - the final production facilities were located in countries other than the original source of the technology. The technology involved in these cases was relatively "advanced" (automotive components, industrial chemicals, complex consumer durables, office equipment, aerospace engine bearings, etc).

As can be seen various types of engineering activity accounted for about ten per cent of total costs, and most of the remainder consisted of the costs of producing, constructing and installing the various types of plant and equipment which make up the physical facilities of the plants established. A broadly similar pattern is shown in Table 2 below. This information relates to two different kinds of investment project in developing countries. Both cases involve the transfer of existing technology, and again, the supply of capital goods (buildings, infra structure, machinery and equipment) accounts for the main bulk of costs. However, there are important differences between the two types of project. The construction of a pulp and paper mill involves a substantial amount of on-site plant fabrication and equipment-integration to create a continuous process plant. A textile mill, on the other hand, usually involves the specification of standard equipment items within an overall plant design, together with the acquisition of these, and their relatively simple installation in the facility. As a result the provision of engineering, erection, pre-operation and start-up services accounts for only about 7-12 per cent of total costs in the textile case, but for 25-35 per cent in the pulp and paper case.

Table 1: Structure of Costs in Investment Projects: Involving International Technology Transfer

	Chemicals and Petroleum Refining*	Machinery**	Whole Sample
Transfer of research results and design fundamentals	1%	1%	1%
Engineering and design, production planning	10%	8%	9%
Construction, tooling and installation	81%	63%	75%
Manufacturing start-up	7%	28%	14%

* Includes projects in ISIC categories 3511, 3521, 3530, 3560

** Includes projects in ISIC categories 3819, 3825, 3829, 3831, 3832

Source: D J Teece (1977).

Table 2: Structure of Costs in Investment Projects: Typical Textile and Pulp & Paper Projects in Developing Countries

	Textiles*	Pulp & Paper**
Infrastructure and Site Development	2-3%	2-3%
Civil Engineering and Buildings	15-20%	15-20%
Machinery & Equipment	60-65%	40-45%
Erection	3-4%	10-15%
Engineering, Pre-operating Expenses, Start-up	4-8%	15-20%
Interest during Construction	5-10%	10-15%

* Approximate figures for a spinning and weaving mill of more than 15,000 spindles.

** Approximate figures for a bleached sulfate pulp and printing and writing paper mill of a capacity of 200-300 tons per day.

Source: Amsalem, M.A. (1978), P.200.

Quite clearly the relative magnitudes of the different types of technological resources that are involved in investment projects will vary quite widely, both between different types of project and between different types of recipient country. Despite this variation, the above discussion suggests a number of useful points. Interestingly, except for the pulp and paper project, engineering costs are relatively low, accounting for, at most, 11 per cent of total costs. This low share might seem to superficially contradict the importance usually attached to engineering activities in effecting technological transformation. However, the figures hide two important relationships. The first is the linkage between engineering and equipment specifications and supply that we discussed in the Lectures

Five and Six. Control over the engineering functions often yields control over subsequent functions which have a greater cost element. Because of this, the value of decision-making incorporated within the engineering function is certainly much higher than the costs/man hours involved in actually doing the engineering itself. The low share of engineering costs in total costs probably reflects the fact that the supplying firms have extensive engineering expertise and experience and are relatively efficient suppliers of those services developing country recipients were responsible for, then engineering costs would probably rise but we have no way of judging this on the evidence available. If the case for building up engineering capabilities is going to be made clear, the level of analysis has to be taken beyond the degree of disaggregation contained in these studies.

Another important point is the uniformly high share of costs associated with the production of plant and equipment. Clearly, investment projects generate a substantial flow of demand for these types of services. If a country were interested in reducing its investment related foreign exchange costs, then obviously these figures suggest that a good place to start would be by considering the pattern of demand for capital goods likely to be generated by future investment projects. This is a straightforward import substitution type argument of course, with the difference being in the character of the "goods" being provided locally. The specification and production of capital goods can generate important externalities, and the importance of the sector is widely recognised as is the current pattern of substantial Third World dependence on imported equipment and capital goods, most of which is associated with new investment projects.

A third factor that seems to be important is the relative lack of any expenditure on R & D in establishing these facilties. One explanation of this is that all of the projects reviewed in these studies tended to involve fairly standard (albeit sometimes complex) techniques. Thus the "innovative" content of these projects is quite low - in other words the firms carrying out the transformation activities did not have to engage in any R & D to generate entirely new knowledge. All they had to do was draw on already existing stocks of knowledge.

Unfortunately, little information is available about the "innovative" content of investment projects in industrialising economies. Some fragments are available. For example, Cortes (1976) reviewed the technological dimension of investment in petrochemical plants in Latin America. She distinguished between two possibilities for the early stages of the processes involved: the use of existing technical knowledge and the creation of new knowledge. The latter would involve various kinds of R & D activity, but: "in the establishment of petrochemical projects in Latin America this route has been used on extremely few occasions".

Some further light is shed on this question by information derived from the unpublished results of a survey of technological aspects of industrialisation in Thailand in the late 1960's and early 1970's. Table 3 below provides data on the innovative content of both the product and process technology involved in a sample of investment projects. In only two cases out of fifty (4%) did the production-process component of the projects involve any "innovative element" at all, and in only one of these two cases did that innovative element require any kind of R & D activity for its development and incorporation into the system. Relevant information about the product technology component of the systems was available for only 47 of the projects. In only eight cases (17%) did this involve any "innovative element", and in only two of these (4% of all the cases) was any kind of R & D activity involved in generating that innovative content of the product technology.

Table 3: Innovation and R & D Content of Industrial Investment Projects: Thailand 1960's and early 1970's

	Proportion of Projects in Each Category	
	Process Component Investment	Product Component of Investment
With no Innovative Content	96%	83%
With some Innovative Content	4%	17%
- Not involving R & D	2%	13%
- Involving some R & D	2%	4%
Total Number of Investment Projects	50%	47%

Source: Unpublished SPRU study

At one level the above data suggests that in many investment projects R & D skills strictly defined are unlikely to be drawn into use to facilitate technology transfer - therefore the lack of R & D skills does not pose nearly as serious a problem as, say, the lack of machine building or engineering skills. This is important because a great deal of emphasis is often placed on the need to establish a local R & D capacity as a source of technology - if the above evidence is correct it suggests that at least as far as technology transfer is involved (which will remain a major conduit for technology acquisition by developing countries for a long time) local formal R & D skills are not likely to be of much use in hastening the assimilation and mastery of the imported technology. This may vary of course - technology transfer involving the establishment of high technology industries may actually require a substantial transfer of R & D capabilities.

Having at least partially addressed the question of what types of capacity and skills are likely to be required by recipient firms we can now turn briefly to identify the various types of mechanisms that can be used for this purpose. Here we can draw again on the useful discussion by Bell (1982) to describe some of the different mechanisms by which the effective relocation of the skills contained in Flow B can be carried out. Bell suggests that these mechanisms can be grouped into four categories:

(a) The relocation of technical information

The technical principles, knowledge and specifications which underlay particular production facilities may be transferred in "disembodied" form as well as being incorporated into (and in effect hidden within) those facilities. On the other hand, they may not be. If they are, they will then be readily accessible to domestic engineers, technicians and managers. But, whether they then constitute an effective component of the domestic technological capacity will depend on the extent to which those flows of disembodied information are absorbed into the "active" stock of domestic technical knowledge.

(b) Training

To contribute to effective absorbtion of imported technical knowledge, various forms of training may be incorporated into transfer arrangements. These may take the form of active education in the technical principles, etc, underlying the facility, or of training in the skills and expertise required to manipulate such principles and elements of knowledge - to transform them into specifications, to transform those into the concrete components of production systems, to manage those interlinked transformation processes, and so forth. On the other hand, these various forms of training may not be incorporated at all in transfer arrangements - although training in at least a minimum of operating skills will usually be a necessary component of such projects.

(c) Learning

By carrying out technological and techno-managerial tasks involved in transfer/investment projects individuals and organizations can both acquire knowledge about the particular (type of) production facility itself and augment the skills and experience required to manipulate and transform that knowledge into technical systems. Such "learning-by-doing" may merge into more explicit forms of training when projects incorporate organised participation in, but not total responsibility for, particular tasks by individuals and organisations in the importing economy. While flows of learning may be generated in these ways, projects can also be organised in ways which preclude such mechanisms.

(d) "Reverse Engineering"

Even if the technical knowledge relating to a production facility is transferred in relatively embodied form, with significant components of training and learning, it is often still possible to extract the underlying knowledge by running the transformation process in reverse. Equipment may be disassembled to identify the full set of dimensional specifications which it incorporates, and behind those the principles of design involved. Components may be analysed to determine their material specifications and to identify methods used in their production. Product specifications can be extracted from products, input specifications from inputs, and so forth. By reversing the engineering process in these ways, substantial additions can be made to the domestic stock of technical knowledge but, of course, transfer/investment projects may not be accompanied by any such mechanism for augmenting technological capacity in the importing economy.

In the next lecture I shall review the available empirical evidence to assess the extent to which past technology transfer projects have incorporated Type B type flows and relied on the above mechanisms for this purpose.

LECTURE NINE

THE INVESTMENT PHASE: UNDERSTANDING AND ANALYZING THE TECHNOLOGICAL DIMENSION OF THE TRANSFER PROCESS

Introduction

In Lecture Eight I presented a conceptual framework for understanding and analyzing the investment phase. This framework is by no means comprehensive in its treatment of all the characteristics of the transfer process and is meant only to act as a starting point for discussion and thinking.

I emphasized a number of features of the investment phase which are perhaps worth summarizing here. First the process of establishing a new production facility involves the progressive transformation of technical knowledge into the elements which make up the plant, ie the physical plant and equipment, operating procedures and guidelines, input and output specifications, etc. This transformation process is set in motion and controlled by a series of techno-managerial decisions and actions which for each stage determine what is to be done, how it is to be done, who is to do it and which also monitor the activities themselves.

Second, I suggested that where the establishment of new production facilities in developing countries are involved, the large bulk of transformation takes place within and/or under the control of the suppliers. The straightforward objective of much policy and discussion in the past has been on how to redress this imbalance in the location of transformation activities to ensure that more of these take place within and under the control of developing countries.

Third, though this general sentiment is fine as far as it goes it tells us little about precisely which types of activities (and the skills required to carry these out) are most important and need to be brought under local control. I suggested that the emphasis on creating R & D skills and facilities as a major element of technology policy which is found in much of the "technological self-reliance" literature may be misplaced, and that other skills such as engineering and machine building may be more important.

Finally I re-emphasized the crucial distinction made in Lecture Four that technology transfer involves two types of flows of technological resources - the skills, knowledge and experience that ultimately become incorporated into the production facility and its operating systems; and those skills which both underlie the creation of the different embodied and disembodied elements of the facility and which also allow these elements to be changed, adapted and improved over time.

Given the fundamental importance for a country of being able to undertake innovative activities to meet national and local objectives, I further argued that policy and research attention must be focussed on first assessing the relative size of the two flows of technological resources that occurred in past and present investment projects; and to explore the development of policy tools which will maximise the size of the flow of skills which contribute to strengthening the stock of the technological change-related capacity in the economy and in local firms.

In this lecture, I turn now to consider the available empirical evidence relating to the experiences of developing countries in acquiring industrial technology. I shall be relying almost exclusively on case-study material from a selected number of Third World countries. The size of our "sample" is necessarily limited simply because relatively few studies have been carried out which provide a detailed analysis of those aspects of technology transfer with which we are concerned. Hence the generalisability of the discussion and the information presented is somewhat limited. Nevertheless I believe that the available information provides a good starting point for analysis and discussion. The case studies will be introduced in two parts.

The first section documents the more common situation where developing country recipients have failed to exploit the learning potential of the transfer process with the result that flows of Type B resources have been fairly limited. The second section reviews a much more selected body of evidence of cases where technology importers have attempted and been relatively successful in acquiring technological capacity as well as production capacity.

1. Missed Opportunities in Technology Acquisition

As noted in Lecture Three both the mainstream technology transfer literature and many past policy initiatives focussed on only one dimension of technology transfer - the short run problems of high priced technology acquired under restrictive contractual conditions from foreign, mainly TNC, suppliers. (See also Bell, (1986). Much emphasis was placed on the need to reduce monopoly prices and eliminate restrictive clauses. Beyond that, as the following quotation from Enos suggest, there has been very little interest in what transpires after the contract was signed:

> Once contracts have been signed, concern over the absorption of the technology into the importing country seems often to lapse, at least on the part of those who made the decision to adopt it. Construction and initial operation of inputs and the delivery of outputs is not expedited, training is not conducted and improvements not secured, and the full capabilities of the equipment are seldom realised ... one suspects that the attention of the policy makers in these ... developing countries was not directed towards achieving efficient operation of technologies already imported, and plants already constructed. The energies of those who participate in the decision to import one technology

> shift towards the next possible import. Enos (1982), p. 77

Enos came to these conclusions after comparing the South Korean experience and approach with that of other developing countries. Unfortunately I am forced to agree with his assessment. By and large it does appear as if many developing country recipients have failed to, or been prevented from exploiting the learning potential of the transfer process to the eventual detriment of subsequent production activities. Let me now draw on evidence from a wide variety of countries and sectors to support this somewhat gloomy assessment.

Zahlan (1978) has examined the patterns of technology acquisition in the Arab world from the nineteenth century through to more recent times. He the term "technology-free transfer" to describe the essential characteristics of the process of importing industrial technology throughout this long period. For example, the substantial programme of industrial investment stimulated in Egypt by Muhammad Ali in the first half of the nineteenth century depended on imported "technology". However:

> Muhammad Ali's programmes for the acquisition of technology were totally dependent on foreign manpower; the technology was not transferred to the population to render them self-reliant as to conceptualisation, operation, management, planning or construction. (p. 8)

Not only was the subsequent operating efficiency of the various plants usually very low, but this succession of "technology-free transfers of capital goods" contributed little or nothing to the local "capacity to sustain and upgrade the activity and the capacity to continuously introduce appropriate innovations no matter where these innovations originate." (p.11).

From his survey of the patterns of technology acquisition in the petroleum and petrochemical fields in more recent years, Zahlan reaches the following conclusions:

> ... the execution of projects in the petroleum and petrochemical fields is essentially a technology-free transfer of capital goods. The same type of plant is repeatedly "transferred" as a commodity. In some cases staff is trained to operate the facilities. But there is little technological participation in the planning and execution of projects. The similarity with the pattern of execution of Muhammad Ali's projects is striking.

Moreover,

> The pattern of executing projects has not changed over a period of at least fifty years, indicating that there is no effort to establish and develop institutions and manpower on a scale commensurate with the demand or need. Although the petroleum resources of the region have been known to exist for more than

> fifty years the technological dependence today is not significantly different that it was in the 1930's, with the exception that local manpower now carries out aspects of exploratory work and production. However, the technology itself has expanded considerably and the acquired expertise is not commensurate with the scale of the activity.

The emphasis within this description on the fact that the output of technology transfer arrangements merely consists of capital goods should probably be modified to take account of the imports of technological services during investment projects. Nevertheless, it is clear that Zahlanis suggesting that the output of "technology transfer" arrangements typically consists almost entirely of the elements of the final production systems. This output seldom includes elements of the technical knowledge (technology) that is embodied in those production systems. Nor does it include either the technical knowledge which is needed to transform that technology into techniques, or the knowledge required to execute the associated decision-making tasks. The transfer dimension of these investment projects appears to have been "technology free", in the sense of having contributed little to the development of technological capabilities in the importing economies.

Evidence from a number of OECD studies of "North-South" (see OECD, 1981) technology transfer by transnational corporations suggests similar conclusions. For example, a report on the rubber tyre industry (OECD, 1981) notes that:

> In the case of the TNC's subsidiaries, very little transfer of fundamental technology takes place. Clearly the necessary formulae and production processes are made available ... But the true value of fundamental technology is not simply the finished formula, but an understanding of how it has been reached so that it can be modified and improved further. This understanding is not transmitted ..." (p. 65)

For the television industry OECD (1979) reports:

> Foreign direct investment involving the local hiring and training of manpower at the engineering and technician level could provide a major vehicle for the transfer of technology in products and processes to those countries. This has not been the case with foreign investment in the television industry. European, US and Japanese firms have retained such skills at home. Subsidiaries in other developed countries employ a significantly smaller proportion of skilled manpower relative to semi and unskilled manpower than the parent companies. The proportions are even worse for the subsidiaries in developing countries. Important skills associated with product and process design engineering are not transferred or hired locally at all.

In another study which concentrates on the content of technology transfer involved in developing countries participation in petroleum exploration contracts, Turner (1982) finds little evidence that skills are being transmitted. The author adopts a similar approach to the one presented earlier by pointing out that in contrast to an earlier period when oil exploration was carried out entirely by foreign firms, developing countries are beginning to appreciate that:

> Without some mastery of oil technology, national management ... cannot ensure that exploration efforts are adequate, that production rates are consistent with national interest ... and that petroleum becomes a vital national growth point rather than a cause of economic distortion ... the domestic formation of basic skills for oil exploration by the countries concerned may be the only guarantee that their hydrocarbon potential, perhaps large enough for local consumption, is tapped at all. (p. 3)

The author specifies four types of skills deemed essential to the creation of an indigenous technological and managerial decision-making capacity in this sector.

> (a) Managerial capabilities for organising and implementing a national petroleum exploration and development programme as a whole;
>
> (b) Technological expertise for taking decisions at critical stages of petroleum exploration and development, such as the ability to analyze and assess the results of geophysical and geological surveys;
>
> (c) Technical capabilities and knowledge of the oil field service and equipment market needed for appropriate policies and practices for procuring them;
>
> (d) Oil field skills, in particular those of "tool pushers" and maintenance personnel. (p. 8)

It is interesting to note that the first three sets of skills all fall into our categories of decision-making/techno-managerial activities the possession of which the author emphasises is absolutely crucial to creating conditions which would eventually allow the accumulation of the more specifically technological skills involved in oil exploration. Turner further notes that technology transfer has not normally constituted a central element of petroleum exploration contracts, and that there is a clear divergence of interests between developing countries seeking to acquire and assimilate exploration technology and those of the supplier firms seeking to maintain Third World oil producers in a state of dependence on their services.

With this approach and set of concerns as a background, 601 petroleum contracts conducted in the 1970's were examined. Four types of contractual provision were identified which could relate to technology transfer:

(a) training and scholarship

(b) employment of nationals

(c) local procurement of equipment and technical services

(d) others

Out of the total of 601 contracts only 88 (14%) contained one or more of these provisions. On the basis of this evidence it is likely that very little effective technology transfer occurred during the implementation of these contracts - ie the main tangible output that the recipient country actually acquired was the information generated by the exploration companies' activities - and even then it would appear that the recipients were unable to properly evaluate these results. However, Turner does note that it did appear that more emphasis was placed on including these terms in contracts concluded in the second half as opposed to the first half of the 1970's. Moreover in one of the categories, training, in the 9% of contracts which contained training clauses, there seemed to be a trend towards increasing specificity of the type of training to be carried out. This was not the same in relation to the employment of nationals where there was no discernible trend towards increasing specificity of the types of jobs to be filled by locals.

There is much more of value in the report but here I only wish to cite the author's conclusions regarding 10 years of experience of developing countries in negotiating oil exploration contracts.

> (i) It is apparent that in most cases exploration contracts have not proved effective mechanisms for the real transfer of technology and for strengthening the technological capacity of developing countries to undertake petroleum exploration ... (although) further improvements may be expected as awareness of the potential increases.
>
> (ii) There appears to be a difference between the formal terms of an agreement and the practical implementation of these terms, especially if they are not quantified or quantifiable. As long as these countries rely on the foreign companies to carry out the technology-transfer-related clauses, the actual effect may be negligible, since the transfer of technology counts very little for these companies as an objective for concluding an exploration contract.[1]
>
> (iii) Exploration contracts display very little specific concern with the four types of technical skills previously identified as critical.

This study clearly is very useful in terms of the approach adopted and the questions asked about the existence or not of the technology transfer related clauses in the contracts studied. However, we must be careful about how much weight is given to arguing that the existence or not of these clauses actually reflects the reality of what subsequently transpired when the contracts were implemented. To judge this it clearly would be necessary (in this sector and in other areas where similar analysis might be carried out) to carry out further research which documents or measures what happened with regard to the technology transfer process itself. As discussed earlier in Lecture Seven, one can conclude little about reality on an a priori basis informed only by the content of contractual documents. Turner echoes this perception in the following quotation:

> In examining the petroleum exploration contracts, it is important to remember that they are negotiated within the framework of the relevant national legislation (eg petroleum act) and that such legislation may oblige inclusion or at least consideration of certain conditions, including those relating to the transfer of technology. If the latter is the case, the inclusion of technology transfer considerations may not actually reflect the willingness of the foreign company to effect such a transfer. Furthermore, though this is obvious, the inclusion of provisions in the contracts does not necessarily mean that they will in fact take place. This may be particularly true in the case of technology transfer provisions which do not form the core elements of the exploration contracts.

I shall come back to this issue below.

Staying in the realm of technological contracts, we can examine some information regarding the nature of resource flows during investment projects carried out in the Caribbean region during the 1970's. This work was carried out by an IDRC funded study called the Caribbean Technology Policy Studies Project. Odle (1981) presents the results of an analysis of 79 contracts covering a wide range of technology transfer projects in Guyana and Trinidad-Tobago. Olde found that these contracts rarely contained any clauses relating to training and/or the provision of design and engineering know-how.

> Such aspects as production know-how and specifications, formulae, problem-solving and promotional assistance occur very frequently in the contracts, whereas personnel training much less so, and provision for (training in) design and engineering (along with R & D) hardly at all.

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1. This point and point (i) both underline the importance of developing an effective monitoring capability to ensure that the objectives of different stages of transfer process are actually fulfilled.

As with the Turner study, this lack of training and other capacity related clauses is indicative that in the contracts reviewed, no provision was made to ensure the transfer of Type B capabilities. However care needs to be taken in interpreting these results as suggesting that no Type B capabilities were transferred at all during Turner's conclusions. However, a much clearer set of results emerges from the work of Farrell (1984), who examined the petroleum industry in Trinidad-Tobago from a perspective which was concerned to assess the degree and nature of the skills acquired from foreign TNC's during their period of operation in the industry. The study did not look at a single identifiable investment project but at the flow of resources between parent and subsidiary/affiliates over a number of years. As mentioned earlier, Farrell employs a number of useful concepts and methods to define his area of concern and to assess the experience of the industry. One set of concepts relates to the notions of static and dynamic technology (similar to our Flows A and B respectively) which we have already discussed, and where Farrell places particular importance upon the acquisition of dynamic technology. He also distinguishes critical from non-critical skills by classifying under the first heading those minimum skills necessary to run an industry in the short run. He then generates a list of 17 functions or activities necessary to the functioning of the industry, which he further subdivides into 48 different specialised skills.

By means of a methodology described in detail in the text of his article, Farrell then assesses the degree to which Trinidad now possesses dynamic technology in those areas as a result of the operation and efforts (or lack of them) of TNC's and associated technology suppliers. He concludes that after nearly 100 years' experience in oil production, Trinidad-Tobago suffers from "certain serious weaknesses in the area of dynamic technology ... of two kinds: "Depth" weaknesses where the country possessed some staff with skills in a particular area, but obviously not enough; (and) "breadth" weaknesses where the country either does not possess a wide enough range of skills to service particular functions, or possesses no apparent skills at all in certain areas." p.266.

Out of the 17 functional categories earlier identified, Farrell argues that Trinidad-Tobago has little or no dynamic technology in 11 categories. In the following five categories, breadth weaknesses were identified - Major Projects and Construction, R & D, Economics and Planning, Transportation (Marine Tanker) and International Marketing. Depth weaknesses were identified in the following 6 categories - Exploration, Marine Production, Petrochemicals, General Administration, Purchasing and Information and Data Processing.

A number of other studies were carried out in the Caribbean region which used the same methodology as Farrell and appear to have come to more or less to the same conclusion. Farrell and Gajraj (1984) looked at the vehicle assembly industry in Trinidad-Tobago and concluded that the:

> Technology transferred under the assembly industry's technological arrangements was not the technology key to the ability to actually manufacture vehicles. The level of skills was both low and static ... the industry has made little contribution to the country's development of a technological capability with respect to the automotive industry. (p. 90)

Bardouille's (1984) examination of the bauxite/aluminium industry in Jamaica and Guyana is slightly more positive. In Jamaica it was found that after 25 years of operation, the country possessed a good deal of skills in the area of static technology and some in dynamic technology. In the most critical functions of the industry, Bardouille found that often there were locals involved in operational positions but not in senior technical and managerial positions. The author's research also suggests that technical change capacities were also lacking since although there is an R & D and technical services division in the companies, the work carried out is relatively marginal. Major technical change activities take place abroad in the central R & D facilities.

A similar situation was found in Guyana though there, following nationalisation in 1971, the national company had attempted to develop a certain degree of independence in a variety of important areas. Technology transfer contracts in the mid 1970's were entered into for the supply of mining design services, equipment and spare parts with a variety of foreign suppliers. Training clauses were included but these were apparently only for the training of local personnel in operation and maintenance of the imported equipment.

De Castro (1984) examined a series of technology transfer projects in the petrochemical sector in Trinidad and Tobago and describes arrangements whereby US firms W B Grace, Fluor and Amoco built a series of fertiliser plants between 1960 and 1975. The analysis shows clearly that though four plants and a number of expansion projects were undertaken, virtually all of the technological transformation and techno-managerial activities remained under the control of the foreign suppliers. Some vague provisions for training were contained in some of the contracts, eg the supplier undertook to establish long term training of "artisans, mechanics and office workers from the local population, b*ut also eventually, and to the extent possible, certain senior staff personnel*", p.129 (emphasis added). However de Castro concludes there is no real evidence that the company did undertake long term training. As a result the Government of Trinidad and Tobago "still has no expertise in either ammonia plant design or its operation".

It seems clear from the evidence reviewed above that technology transfer projects to the Caribbean region have in the past at least contained very little of the Type B flows of technological capacity, and even Type A flows of static technology have been limited. Allocation of responsibility for this state of affairs is somewhat tricky. The studies show clearly that the TNC's were not very interested in transferring technological capacity along with the hardware they supplied. This in a sense is to be expected. It is however also clear that the recipient firms and host governments made little if any effort to include effective and enforceable arrangements to transfer technological capacity in the deals they negotiated with the suppliers. The recipients must therefore bear a large share of the responsibility for the crippling lack of technological capacity in the Caribbean region.

Turning away from the Caribbean experience, we can look in more detail at two further studies which are interesting both for their results and because they adopted different research methodologies from the studies reviewed above. The first, Mlawa (1983), examined the evolution of the textile industry in Tanzania over the 1960-1980 period and set out, in part, to examine the principle mechanisms used "for the acquisition and subsequent accumulation of technology and techno-managerial capacities in the industry". (p.1)

In examining the investment phase, Mlawa first concentrated on assessing the level and nature of training undertaken during the transformation process. He looked first at the training related clauses specified in the contract and was interested in the existence or not of three types of clauses - (a) those covering training for ongoing operation and management (Type A flows); (b) those related to training for the execution of technological and managerial tasks for future investment projects (Type B flows); and those related to carrying out technical change activities (Type B).

He found that over a period of 15 years none of the contracts contained any specific reference to training clauses related to Type B flows. Moreover he found that this omission was not imposed on the recipient enterprises but that "as far as we could ascertain no demand for training for these types of skills, etc had ever been expressed formally and systematically by Tanzanian agencies ... The acquisition of these resources was a very low priority for those concerned with the development of the industry". (p.7-8)

As far as clauses related to Type A flows, Mlawa found that most contracts did include clauses related to this type of training. These were only very generally specified and related only to the transfer of the basic minimum skills necessary to operate the plant. Rarely was any training supposed to be provided for higher levels of management or in areas like textile engineering and product design.

Mlawa also went beyond the details of the contracts to examine the nature of the training that did take place. Some of the results of this analysis are set out in Table 1 and show clearly that actual degree of training even in basic operational skills was much lower than had originally been planned for - a result of local managerial control over project implementation being so "loose" that the suppliers "could choose to carry out much less than was specified - or even to carry out virtually nothing at all". (p.11)

Mlawa's examination of the characteristics of the investment phase went beyond simply looking at contractual clauses. He also attempted to assess the degree to which Tanzanian recipients were able to undertake a greater share of the provision of technological and managerial inputs in successive investment projects over time. He started first by desegregating the different types of investment inputs required to establish a textile mill into 22 categories as shown in Table I. He then ascertained the relative balance between the foreign versus the local supply of these inputs through a series of separate investment projects. His results are set out in Table 2 and show that in the late 1960's, none of the 22 inputs were obtained from Tanzanian suppliers - and by the late 1970's virtually nothing had changed. The only categories in which a local supplier was involved was in the area of buildings and infrastructure - and even then the main contractor was Tanzanian in only two out of six projects.

Mlawa also examined in more detail the question of who was responsible for taking and implementing decisions and managerial tasks during these projects. As with the supply of technological inputs, he found that the degree of Tanzanian involvement in these tasks was minimal and did not increase overtime so that by the end of the 1970's after 15 years' involvement in investment projects in the textile industry "Tanzanian institutions played virtually no role at all in decision making and managerial tasks relating to any of the technological inputs for investment in the industry". (p.9). It is sobering to note that this whole process (or lack of a process) occurred during a period when the Tanzanian Government placed a great deal of emphasis on achieving technological self-reliance - clearly something more needed to happen in Tanzania to achieve this than mere statements.

In a study which followed a similar methodology, Ahmed (1983) examined the evolution of the fertiliser and pulp and paper industry in Bangladesh over a 25 year period between 1957 and 1982.[2] Ahmed's results, as shown in Table 3 are painfully similar to those of Mlawa. For the fertilizer industry, over the course of a number of years during which nearly identical plants were built Ahmed found there was no shift with respect to the (local supply of the) main technology transforming tasks (ie designs, equipment production, installation, commissioning etc).[3] The same was found to be true in relation to three paper mills set up over the same period. Only in the area of Bangladeshi involvement in techno-managerial tasks does there appear to have been a slight increase over time.[4]

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[2] Ahmed (1983) also contains very useful descriptions of case studies on the accumulation of technological and techno-managerial capacity by UK firms.

As in the Tanzanian case, when Ahmed examined the degree of training provided for and carried during the investment phase of the fertiliser and paper mill projects, with the exception of the most recent plants, he found provisions only for operations related training and not for the transfer of Type B skills. The pattern of training that occurred is set out in Table 4, and on the basis of this he concludes that "technology transfer associated with investment in these industries seems to have contributed very little, if anything to the "dynamic" technological capacity available in Bangladesh ... during the ... 1950's and 1960's, and most of the 1970's Bangladesh capacities to use technical knowledge for carrying out the technological and techno-managerial tasks involved in investment in new plants was augmented very little, if at all, by technological transfer." (p.178). Ahmed was also able to document the short run foreign exchange costs associated with the investment projects in the two industries. His results, summarised in Table 5 show clearly one dimension of the costs imposed on the local economy by the lack of indigenous capacities and the resultant need to depend on imported know-how and services. And rather than decreasing overtime as one would normally expect, the proportion of foreign cost in total project costs actually increased overtime - despite the fact that local costs grew more than three times as fast as foreign costs for capital goods. It is important to note that the expenditure of scarce foreign exchange during the investment phase represents only one element of the costs associated with the lack of a local technological capacity. The other and much larger elements are the costs associated with low or declining rates of capacity utilisation of the plants once they are established.

By way of summary of the evidence presented so far, it appears that in a very wide number of cases, particularly in the poorer developing countries, there has been a systematic failure on the part of the recipient enterprises/host Governments both to exploit the learning potential of the transfer process and to achieve an increase in the degree of local supply of technological inputs. This failure has for the most part been matched by a limited or totally non-existent local involvement in techno-managerial activities associated with investment projects with the result that control was vested in the hands of foreign suppliers. Perhaps most alarmingly there does not appear to be any significant improvement in these parameters over long periods of two to three decades, during which the countries have been involved in a succession of technology transfer events within the same set of industries.

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3. Ahmed found a similar situation when he examined the provision of technological input for technical change projects in existing as opposed to new plants.

4. Though interestingly in the one example in the mid 1970s where some engineering services were provided locally subsequent investment projects reverted to a greater dependence on imported inputs.

The reasons for this lack of improvement are in some cases open to conjecture. However, I tend to agree with Mlawa, that a large measure of responsibility for this sad state of affairs must lie with the failure of host Governments/recipients to effectively express their demand that technology transfer projects should contribute more to the local economy than simply augmenting production capacity. An interest and concern to secure training in middle and higher level technical and managerial skill categories seems to have been totally lacking. And as I shall show in the next section, not only has this situation resulted in the countries studied having to spend huge amounts of scarce investment resources on securing the supply of foreign inputs, the subsequent operation of the plants so established often represents a continuing and in our opinion totally unnecessary drain on resources.

2. Exceptions to the Rule

Contrary to the impressions given by the discussion in Section 1, there are in fact a number of examples where developing country recipients have been much more successful in using investment projects to build up their stocks of technological capacity. This is the evidence that I review below. One point worth mentioning at the outset is that with one exception all the examples come from the more advanced developing countries where industrialisation is reasonably far advanced and where the degree of technological development is high compared to most of the Third World. While this limits the immediate transferability of the precise experience of these countries, these studies are nevertheless illuminating and provide many generally useful insights which can only be appreciated through reading the full texts. Here I shall emphasise those aspects which relate to the discussion in the previous lecture. In particular, I suggested that there were four types of mechanisms through which technological capacity can be transferred and accumulated:- the relocation of technical information, training, learning and reverse engineering. The cases described below provide examples of these different mechanisms at work in varying combinations and configurations which I will highlight as they appear in the studies.

The transfer of US aerospace technology to Japan

Hall and Johnson (1970) examined the experience of Japan in acquiring aerospace technology from Lockheed in the US. The authors set up an analytical framework to assess technology transfer which distinguished between flows of three types of technical information that cut across the Type A & B flows discussed earlier:

> General technology refers to information common to an industry, profession, or trade. At one extreme this category includes such basic skills as arithmetic, and at the other such specialised skills as blueprint reading, tool design, and computer programming. The same general knowledge is possessed by all firms in an industry and hence is the ticket of admission to the

industry.

System-specific technology refers to the information possessed by a firm or individuals within a firm that differentiates each firm from its rivals, and gives a firm its competitive edge. Some of this specific information will have been acquired through engaging in certain tasks or projects. It comprises ingenious procedures connected with a particular system, solutions to unique problems or requirements, and experiences unlike those encountered with other systems. System-specific technology is when a firm, in manufacturing an item, acquires information that is peculiar to that item.

Firm-specific knowledge differs from system-specific knowledge in that it cannot be attributed to any specific item the firm produces. Firm-specific knowledge results from the firm's overall activities. For example, a firm may have special capabilities in thin-wall casting or metallurgical techniques not possessed by other firms, and not necessarily attributable to any specific item the firm has produced.

To illustrate the difference among the three types of technology, some of the information required for the manufacture of, say, the F-5 aircraft is common to all firms with an aircraft manufacturing capability; this we call general technology. The particular firm that manufactures the F-5 has acquired some specific information about this system not possessed by other firms; this is system-specific information. Certain other technology is possessed by this producer that other firms do not share, but which is not attributable to the F-5 (or other specific system); this is the producer's firm-specific knowledge.

The authors suggest that the effectiveness and costs of technology involving these different types of technical knowledge depend on a number of factors -

(a) the degree of industrial skill which the recipient already possesses;

(b) the nature of the technology and the form of its embodiment - general technology because of its breadth and differences may be the most difficult to acquire while system-specific technology embodied in blueprints and drawings will be the most expensive but the easiest to transfer;

(c) the willingness of the supplier of the technology, which depends in part on the financial inducements offered and the importance of the technology as a source of quasi-monopoly;

(d) finally, Hall and Johnson emphasise that the key to the success of the Japanese in acquiring technology lies in their ability to make difficult decisions about what and how much technology to acquire and about the best mechanisms to do this. "Correct decisions importantly affect the success and costs of international transplantations of technology". (p.306).

The empirical part of the study in which we are interested highlights the way in which the Japanese Government and recipient enterprises imported aircraft technology through "co-production" programmes by which the suppliers provided full access to all inputs necessary to allow local production of aircraft. This involved the transfer of technology from an already established industry in the US, to set up a new production facility in Japan.

The transfer mechanism used in the co-production programme consisted of a number of elements which relate roughly to the mechanisms mentioned earlier. Data packages on corporate policies and practices were provided (firm - specific knowledge) which involved much detailed information (often contained in manuals) on managerial, drafting, planning and other procedures. Transfer of system-specific information involved the provision of all product and process designs and trading specifications as well as the notes and black books of foremen.[5] Both of these involved the relocation of technical information and led to a considerable degree of learning by reverse engineering as the Japanese "pulled apart" the imported specifications and machines in order to understand the basic principles and to allow the subsequent local supply of the inputs.

Extensive training both abroad and in Japan was undertaken at all levels of production and management involving many thousands of man hours in both conceptual and "hands-on" types of training activities.

Some formal training was used but the large part of the transfer through this mechanism came through day-to-day involvement of foreign and local personnel working together to perform specific tasks and overcome problems. One supplier, Lockheed, used what it called a "counterpart" programme to transfer people embodied knowledge. "Each man who went to Japan was assigned a counter-part Kawasaki employee at the supervisor level and an interpreter". The Lockheed and Kawasaki teams involved in establishing production were therefore fully integrated. This allowed full participation of both sides in the process and proved to be highly successful when compared with strategies followed by other suppliers who did not integrate their teams but acted as sources of technical assistance when asked by the recipient.

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[5] The point made about the provision of foreman's notes and black-books is particularly interesting. It shows the fine attention to detail required to effect the transfer of know-how, and shows also the value of the author's detailed observation/research method - we know of no other study where this transfer made is mentioned.

Other aspects which are emphasised is the importance of a phased programme of transfer. Planes were shipped to Japan in increasingly less assembled CKD form and assembled by the Japanese. Gradually CKD kits were replaced by the shipment of components as Japanese assembly skills were developed. This in turn was followed by a gradual increase in local production of previously imported components. In this way tight production schedules were met while at the same time the Japanese learned assembly and production techniques. Clearly, to allow these schedules to be met, careful planning was required to allow the development of Japanese absorptive capacity in advance of the point at which they assumed responsibility for the next stage of activities.

The authors also emphasise the importance of the provision of full tooling technology (the relocation of technical information) - either in the form of the tools themselves or their design specifications. These techniques and the changes made to them embody much of the production technology of the supplier and their eventual local supply (through reverse engineering) meant that the Japanese were also subsequently much better able to modify and adapt their product designs by being able to modify the tooling required to produce components.

Hall and Johnson go on to examine the subsequent transfer of more advanced airplane technology in great detail but which I will not discuss here. However, they stress the importance of the earlier co-production programmes in providing Japanese firms with the general and system-specific capability needed to move into more advanced production. Their analysis makes clear that the transfer of product technology involves a variety of knowledge flows covering a vast number of component parts and materials. To transfer this body of knowledge effectively requires the commitment of large numbers of personnel and very considerable costs on the part of both suppliers and recipient.

Particularly important within these are the reservoirs of knowledge and experience embodied in people which can only be transferred through intimate, sustained contact between suppliers and recipients through the whole of the investment phase. Hall and Johnson concentrate most of their analysis on documenting the mechanisms and costs involved in transferring what we have called Type A capabilities. However, it is clear that by so extensively involving themselves in acquiring the technology that the Japanese were also adding substantially to their stocks of technical resources which were subsequently drawn upon in importing and adapting the more sophisticated aircraft technology described in the second half of this paper. The two flows of Type A and Type B technology were clearly explicitly intermingled in the design and implementation of the transfer process because the Japanese fully intended to become capable of the independent production of particular types of aircraft and inter alia be able to effect the technical changes necessary to adapt and improve product and process technology over time.

The Indian experience in steel and machine tools

If we turn to the developing country case materials there are two studies which have documented the role of technology transfer in the evolution of the Indian machine tool and steel industries. Dastur (1978) describes the technology transfer programme undertaken during the establishment of the Bokaro steel plant during the 1970s.[6] Although the transfer activities undertaken included a wide range of capacity creating mechanisms, of particular interest is the manpower training programme that was pursued.

India's earlier experience in setting up steel plants gave Bokaro's planners some idea of the magnitude of the manpower and training requirements needed to start up a new plant. Although some personnel could be drawn from other Indian steel plants, most had to be trained specifically from Bokaro.

To meet these demands, Indian planners choose to create their own specialised training institute rather than be dependent on training people in the Soviet Union. The various internal training programmes carried out under this scheme were as follows.

While 50% of this training was concerned with Type A rather than Type B skill categories, the programme itself is significant because of the obvious care that went into its design and specifications, and because considerable emphasis that was placed on training prior to the commissioning of the plant in 1977. Table 6 shows the breakdown of people in different skill categories trained prior to 1977. Some foreign training was necessary - about 370 people received specialised training in production know-how and technologies in the USSR - however, this was much lower than it might have been.

Turning now to the machine tool sector, Mascarenhas (1982) describes in great detail the technology transfer experience of Hindustan Machine Tool, a public sector enterprise established in 1953 and now one of India's most powerful and diversified capital goods manufacturers. Mascarenhas assesses the very wide variety of technology transfer projects in which HMT has been involved. His description of the very first project, a joint venture with the Swiss firm Oerlikans to establish its first machine tool production facility is interesting because of the emphasis placed on the way in which this project laid the technological and technology "culture" foundations on which the whole industry has been built.

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[6] Another study of the negotiations phase in the same plant Desai (1972) was discussed in Lecture Six.

> The joint venture with Oerlikans is acclaimed by all as having laid the foundations of the machine tool industry, especially because of the collaborator's emphasis on training, quality, and precision.

In this project the Oerlikans team undertook the following tasks involving training of HMT personnel:

(1) the transfer of know-how for design of tool room lathes;

(2) training in complete project planning;

(3) training in the selection, supply, erection, and commissioning of plant machinery, and equipment;

(4) the supply of jigs, fixtures, special tools, patterns, CKD parts, and castings;

(5) training in the planning of the organisation and setting up of procedures and systems;

(6) training of Indian personnel in Oerlikans and HMT, and the deputation of Swiss experts in all areas of management;

(7) the starting up and running of production by Swiss experts with Indian understudies.

Mascarenhas points out that

> This phase emphasised the training of craftsmen, supervisors, and engineers in the processes of machine tool manufacture and acquiring skills for producing quality machine tools.... The project did not achieve volume production and the financial results were naturally not up to expectation. (p. 66)

However, as a result of the nature of Swiss involvement in this first project, the management of HMT developed an overall perspective on its technological development which consistently emphasised the importance of training and skill development. In terms of planning its future strategy, the management felt that it had to move through four stages of development, all of which necessarily involved technology transfer from abroad but with the crucial proviso that these stages all involve extensive training. At the same time HMT established a variety of skills that it needed to acquire to facilitate effective transfer and set about generating these skills through the creation of a rigorous and comprehensive internal training programme.

HMT saw technology transfer and its internal training efforts moving through 4 stages:

- The "do-how" stage during which basic skills like fitting, turning, milling, etc, were developed in craftsmen, supervisors and engineers with an emphasis on accuracy and quality consciousness.

- the "selective specialisation" stage during which individuals in different positions were given further training in specialised areas and intermediate products such as casting and bearing for craftsmen and supervision and management for more senior level staff[7].

- the "know-how" stage where the stress was laid on the local development of simple designs and the modification of imported technology. Here the emphasis was placed on acquiring specialised skills in areas such as marketing, industrial engineering designs, etc and on improving the organisational structure of the company.

- the "selective technology/know-how" stage where imports of technology are highly selective and which build on already established indigenous production and design capabilities.

Through the evolution of these stages the company adopted four different strategies for acquiring technology from abroad in ways which complemented the types of skill and technological capabilities it was trying to generate internally. These strategies were:

(a) broad based joint ventures for the initial establishment of the industry of the sort entered into with Oerlikans. The main objective here was to establish agreements where the collaborators agreed to assist in extensive training to lay the foundation for indigenous production.[8] "The joint venture of turnkey project is recommended in the early stages of the development of an industry. After the basic plant and equipment are established and the basic knowledge of the technology has been acquired, then the industry should preferably move to other forms of acquiring technology, as HMT has done." (p. 61)

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7. Mascarenhas relates how senior management at HMT reiterated the importance of the first two stages by stating: "Our experience is that the first two stages are very crucial for technology assimilation. Skipping these two stages by deliberately bringing in the most advanced technology with an inadequate supply of indigenous skills will result in progressively increasing dependence on imported technology." (p. 85)

(b) the second strategy consisted of the selective purchasing of technology through licensing contracts. HMT adopted this strategy to facilitate diversification of its product base. Contrary to other views of licensing as mechanisms which increase dependence[9] HMT ensured that its licensing agreements were comprehensive in their emphasis on real technology acquisitions and involved the "acquiring technical know-how through detailed documentation of the designs, drawings, standard sheets etc, and making arrangements for technical assistance by training engineers at the collaborator's works for technicians from the collaborator to assemble and test the product in the early stages." (p. 62)

Mascarenhas makes the important point that to achieve such deals considerable bargaining is required in which to achieve success depends on having a "sound technical knowledge of alternative sources". One of the techniques HMT developed to strengthen its bargaining capabilities was to use a basic format for drawing up all licensing agreements. This greatly facilitated the ability of HMT negotiators to get a good deal and "a considerable amount of effort went into its initial development".

(c) a third and highly innovative strategy adopted by HMT is through "bulk purchases" of technical know-how and assistance paying royalties and often fees. This system of acquiring technology is somewhat similar to a licensing arrangement, except that the licensor shares his know-how in return for bulk orders of machines.

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8. This approach is not common in other developing countries as HMT found when it assisted Algeria to establish a machine tool industry where HMT technicians involved in the project observed that "the Algerians did not associate themselves with their collaborators at all. Instead they waited, as they expected to take over a fully operating machine tool factory, according to the contract".

9. Mascarenhas draws attention to the conclusions of Mytelka (1978) in relation to Andean Pact countries where 98 per cent of firms (owned by Nationals) in chemical and metal industry were unable to produce their own technology. Licensing, it is suggested, creates a psychological environment of dependence. Managers become accustomed to rely on imported technology and incorporate the assumption of technology imports automatically in future planning ... obviously HMT managers did not view licensing in this light at all.

Under this strategy, HMT was concerned to exploit external circumstances governing the supply of technology and its strength as a public enterprise. It used this strategy in acquiring a variety of technologies to produce machines needed by the Government. Moreover, it acted as a technological gate keeper in selecting and diffusing technology through the economy.

(d) Finally, HMT is now at a stage of technological sophistication where it finds foreign firms unwilling to participate in licence agreements because of the likelihood that HMT (now a major exporter of capital goods) will quickly become a competitor in the international market. Consequently, it is increasingly resorting to "joint development projects" where both HMT and a foreign firm collaborate in designing new equipment for the Indian and export markets that does not threaten the foreign firm's position.

Technology acquisition in Brazilian Petrochemicals

The final example I wish to discuss has already been introduced - because of the technology transfer strategy pursued by Petrobras and Pretroquiza of Brazil. In Lecture Six, drawing on Sercovitch (1980), I described how Petrobras had a selected a technology supplier willing to provide it with full access to core technology.

Once the negotiations had been completed and the actual investment phase had begun, Petrobas allocated a team of 20 professionals to the technology transfer project. Because of the demonstration value of this exercise for my purpose, I reproduce below Sercovitch's analysis of what subsequently took place during the transfer process itself but where the opportunity to do what is described below was created by the strategy Petrobras pursued in the pre-investment phase.

> These engineers had little experience with ethylene units, but they were experienced in other types of projects. So they spent almost four months studying existing Brazilian ethylene facilities before going to France. They focussed on Kinetics and other critical areas.
>
> Once in France they spent about one month in Paris studying the fundamentals of ethylene units. This completed the first stage of their training program.
>
> During the second stage, the ethylene units (were) analytically divided into characteristic sections and the engineers proceeded to carry out process calculations regarding each different section. The mechanical engineers were included during this phase due to their past experience in process engineering.
>
> Then 5 out of the 20 Brazilian engineers were sent to the Netherlands to work with KTI for two and a half months with

> furnace processes. Two of these five engineers went to visit experimental units in Ghent. After this, they returned to Brazil where they verified all calculations with actual projects undertaken in Brazil (this was one of the specific requirements posed by PETROBRAS to the suppliers).
>
> The 15 engineers who remained in France focussed on the definition and calculation of process equipment. Other areas were left for the following stage. All of their work was related to actual, already completed projects.
>
> Altogether, the training program abroad by CENPES' personnel took some 1,234 man-hours. Including pre- and post-training in Brazil, the length of the program was about 14 months. Once Technip regarded the training program as completed the head of the Brazilian team asked the French company to supervise their calculation of a complete ethylene project for Brazil, which they did.
>
> By October 1978, the computer programs had already been fed into PETROBRAS' computers. Most of the software transfer had this taken place. In addition to the training programs, some 40 man-months of technical advisory services were included in the deal ... (which, at a certain point involved some 200 of Technip's engineers working simultaneously).
>
> In addition, the contract also included a training program for two private (Brazilian) engineering companies.... These companies, which are primarily involved in the detailed engineering of DEMAP (the particular ethlyene plant being constructed), sent 14 people to rance to receive training for 10 months. Although they are in charge of most of the detailed engineering work, the ultimate responsibility for it lies with Technip/KTI, who perform on-site supervision in their role as prime contractors. (pp. 39-41)

Leaving aside the training provided for the two private engineering companies the benefits that Petrobras gained from the deal can be summarised as below.

- technical assistance (including that concerning future plant exports by PETROBRAS and adaptation of Technip's computer programs to PETROBRAS' computer system)
- complete access to all details concerning engineering and scientific data, including methodologies, computer memories, process correlations, simulation models, manual of use and application, etc.: altogether some 60 volumes with 200,000 pages
- design of experimental units and technical assistance for R&D activities

- access to all improvements that the licensor may develop during the next 10 years

- massive training and retraining at the supplier's R&D and other facilities

- acquisition of rights to build, sell, and install ethylene plants in Brazil and any foreign country after 10 years

Obviously to capture these sorts of gains Petrobras had to make a sizeable investment of financial and human resources. However, it is most important to note that Petrobras and the World Bank agency providing funding for the project (IADB) did not see the technology transfer programme as simply involving sunk costs that wold only be recovered over a long period. In fact, these agencies carried out a feasibility study which quantified the costs and benefits of this unique exercise and demonstrated that a high rate of return could in fact be obtained from this type of organised learning experience. Clearly, as the above list of benefits shows, the actual implementations of the project did, in fact, justify the investment and validate the conclusion of the feasibility study.

Table I : Classification of the technological and techno-managerial inputs to investment in Tanzanian textile mills

BASIC SERVICES AND GOODS	Stage 1: Initial Techno-economic studies	Preliminary Studies	1
		Fesibility studies	2
	Stage 2: Project Engineering	Outline Engineering	3
		Detail Engineering	4
		Civil Engineerng	5
		Preparation for procurement	6
	Stage 3: Capital Good Production	Machinery and Equipment	7
		Buildings and Infrastructure	8
	Stage 4: On-site installation and start-up	Equipment assembly, installation and commissioning	9
		Labout Training	10
		Production start up	11
OVERALL MANAGERIAL AND DECISION MAKING INPUTS	Identification and selection of input suppliers	Project Management Suppliers (PMS)	1
		Study and Engineering Service Suppliers (PES)	2
		Machinery Suppliers (MS)	3
		Construction and Civil Building Work Suppliers (CCS)	4
	Negotiating and bargaining with	Negotiating and bargaining with Project Management Services Suppliers (PMSS)	5
		Negotiating and bargaining with Project Engineering Services Suppliers (PESS)	6
		Negotiating and bargaining with Machinery Suppliers (MS)	7
		Negotiating and bargaining with Construction and Civil work suppliers (CCS)	8
	Progress Decision-making and Monitoring	Early inter-stage decision-making	9
		Overall progress monitoring and acceptance	10
		Detailed monitoring and supervision	11

Source: Mlawa, 1983

Table II : Classification of Origin of Technology Inputs to Tanzanian Textile Mills

	1966 to 1968				1977 to 1980			
	Initial Mwatex	Urafiki	Mwatex Expansion	Mutex	Tabora Spinning Mill	Ubungo Spinning Mill	Mbeya integrated Mill	Morogoro Polytex
1. SERVICES:								
Preliminary studies	0	0	0	0	0	0	0	0
Feasibility studies	0	0	0	0	0	0	0	0
Outline Engineering	0	0	0	0	0	0	0	0
Detailed Engineering	0	0	0	0	0	0	0	0
Civil Engineering	0	0	0	0	0	0	0	0
Preparation for Procurement	0	0	0	0	0	0	0	0
Equipment Assembly and Installation	0	0	0	0	0	0	0	0
Labour Training	0	0	0	0	0	0	0	0
Production Start Up	0	0	0	0	0	0	0	0
2. CAPITAL GOODS:								
2.1 Machinery								
Blowroom	0	0	0	0	0	0	0	0
Drawframes	0	0	0	0	0	0	0	0
Roving frames	0	0	0	0	0	0	0	0
Lap former	0	0	0	0	0	0	0	0
Ring frames	0	0	0	0	0	0	0	0
Twisting frames	0	0	0	0	0	0	0	0
Winding frames	0	0	0	0	0	0	0	0
Reefing frames	0	0	0	0	0	0	0	0
Cone-winding	0	0	0	0	-	-	0	0
Cheese-winding	0	0	0	0	-	-	0	
Pirn-winding	0	0	0	0	-	-	0	0
Drum-winding	0	0	0	0	-	-	0	0
Warping	0	0	0	0	-	-	0	0
Sizing	0	0	0	0	-	-	0	0
Looms	0	0	0	0	-	-	0	0
2.2 Buildings and Infrastructure								
Main structure	0	0	1	1	0	0	0	0
Sub-contracted items	0	0	1	1	1	0	1	1

Source: Mlawa, 1983 0 = Foreign
1 = Local

Table III : Sources of Technology Transforming and Techno-managerial services during investment in new fertilizer plants in Bangladesh

Services	Plant 1 (1952)	Plant 2 (1967)	Plant 4 (1976)	Plant 5 (1980)	Plant 7 (1982)
TECHNOLOGY TRANSFORMING SERVICES					
1. Pre-investment and feasibility study	4	4	3	3	4
2. Design and Engineering services					
- Process Design	3	3	3	3	3
- Detailed Design	3	3	3	3	3
- Building and other designs	3	3	3	3	3
3. Capital Goods Production	3	3	3	3	3
4. Plant Construction					
- Civil Engineering	3	3	3	1(3)	3
- Installation, Testing, Commissioning, and Start-up	3	3	3	1(3)	3
TECHNO-MANAGERIAL DECISION MAKING SERVICES					
1. Defining the term of reference for any particular stage in the transformation process	3	3	3(1)	2	3(1)
2. Identifying and deciding upon the agents	3	3	3(1)	2	3(1)
3. Negotiation and acceptance of terms	3	3	3(1)	2	3(1)
4. Monitoring and Evaluation and acceptance of output	3	3	3(1)	2	3(1)

CODES: 1 - From within the economy; 2 - Jointly between Bangladeshis and International Contractor/Consultant; 3 - By International Contractor; 4 - Information not available.
1(3) - From local sources with supervision/guidance from external sources.
3(1) - Main services by foreign contractor/consultant, but with some involvement of Bangladeshis.

Source: Ahmed, 1984

Table IV : Summary of Flows of Knowledge Skills etc during the Technology Transfer Projects in Bangladesh

Plants	Overseas Training			Local Training			Comments
	Number	Type	Duration (Months)	Number	Type	Duration	Flow B/Flow C
Fertilizer Plants:							
Plant 1	84	OP.MNT	3-9	350	OP.MNT	3-6	Flow <B only
Plant 2	37	OP.MNT	10 (max)	NA	NA	NA	Flow B only
Plant 4	32	OP.MNT	4-12	110^1 350/450^2	OP.MNT OP.MNT	3-6 3-12	Flow B only
				800	CONS	3-6	Component of Flow C
	4	MNT/INS	12	-	-	-	Component of Flow C
	4	DG and PROC	12				Flow C
Plant 5	60	ER.COM OP.MNT	3-6	400/450	COM.OP MNT	over three years	Flow B + Component of Flow C
Paper Mills:							
Mill 2	5	OP.MNT	3-6	70	OP.MNT (understudy)	over five years	Flow B onlyæ

1. Includes people of supervisory and managerial positions
2. Operators and technicians (approximate number)

Legends: OP - Operation; MNT - Maintenance: CONS - Construction
INS - Installations; ER - Erection; CM - Commissioning
DC - Design; PROC - Procurement.

Source: Ahmed, 1983

Table V : Proportion of Foreign Exchange to the Total Project Cost Required to Import Goods and Services for Investment Projects in Bangladesh

Investment Projects	Date of Investment	Unit	Total Project Cost (at current price)	Proportion of foreign exchange (%)
New Fertilizer Plants:				
Plant 1	1959	Million Rs	244	56
Plant 2	1967	Million Rs	333	49
Plant 4	1976	Million US$	433*	60
Plant 5	1980	Million Tk	1741*	54
Plant 7	1982	Million US$	455*	64
New Paper Mills:				
Mill 3	1966	Million Rs.	75	67
Technical Change Projects:				
Fertilizer Plants:				
Plant 1	1982	Million US$	4.0*	69
Plant 2	1982	Million US$	18.2*	69
Plant 3	1982	Million US$	16.3*	63
Paper Mills:				
Mill 1	1979	Million Tk	305.3*	69
Mill 2	18981	Million Tk	363.9*	74
Mill 3	1981	Million Tk	192.0*	75

* Estimated Costs

Source: Ahmed, 1984

Table VI : Training at the Bokaro Training Institute

Categories	Number trained up to Dec 1976
Graduate Engineers	601
Senior Operatives (science graduates and diploma holders)	658
Junior operatives	843
Artisan trainees	474
TOTAL	2,576

Source: Dastur, 1978

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SECTION TWO

NATIONAL TECHNOLOGY POLICIES AND PLANNING

Six Lectures by Norman Girvan

INTRODUCTION

The six lectures reproduced here are a direct response to the needs and circumstances of researchers and policy makers in the technology field, as they were articulated in a Workshop setting. Also, the treatment takes into account the ideas developed by Kurt Hoffman on the acquisition and assimilation of industrial technology, and the fostering of technical change, at the enterprise level. There is, therefore, an attempt to forge an organic linkage between the macro and the micro; between policy- making at the national level by governments, and the actual technological decisions and behaviour of enterprises relating to investment and production. It is precisely the absence of this linkage that is one of the outstanding features of technology policy-making in the less industrialized and technologically advanced developing countries.

The treatment is not comprehensive, in the sense of trying to deal with every aspect of a "technology policy" or "plan". This is deliberate. There is already a considerable number of excellent materials dealing with this subject. In addition, smaller and less advanced developing countries may simply not be in a position to formulate and adopt a comprehensive policy or plan; because of lack of manpower, or money, or political support. The question arises, what do these countries do? The lectures try to provide some answers to this.

The first lecture provides an introduction and overview to national technology policies. Some suggestions, only partly in a humorous vein, are made for the benefit of the typically isolated and frustrated technology policy-maker in a developing country government. And a case is made for adopting a partial, strategic approach to technology strategy in these circumstances. Then, a schematic approach to the development of a technology policy, either for a specific area/sector or for the country as a whole, is outlined.

The second lecture goes into some detail on the preparatory work to be done before the formulation of a technology policy. Frequently, such preparatory work is either omitted entirely or carried out only in a very perfunctory manner. This leads to the announcement of a "policy" by government officials, which has nothing to do with anything else that is going on, either in the productive sector or in other parts of the government itself.
The third lecture deals with the actual formulation of specific policies. The case is made here for **selectivity** as part of a strategic approach. The crucial question is what (areas and policy instruments) will be selected, or rather **how** will the selection process be made. Discussion of this question forms the main part of this lecture.

The fourth lecture deals with certain key contextual factors which impinge on the content and effectiveness of technology policy. These are (i) foreign investment policy, (ii) industrial development strategy and policy, and (iii) consumption policy.

The fifth lecture, which was prepared by Maurice Odle, deals with the specific policy area of the regulation of technology imports, which is a favourite target of governments at an early stage of technology policy-making. There is an overview of the main measures contained in these regulatory regimes, and a summary assessment of the results achieved by measures of this kind.

The sixth and final lecture deals with the role of engineering and capital goods industries in building up indigenous technological capabilities. These areas are selected both because of their own intrinsic importance, and as example of strategic building block which yield important externalities in a process of technological development. This lecture ends with an appeal to researchers and policy-makers to develop a vision of the role they can play in developing a technology "awareness", and the policy-making process, in their countries.

NATIONAL TECHNOLOGY POLICIES AND PLANNING

1-OVERVIEW

Introduction

This initiates a series of presentations on national technology policies and planning. We will not be able to be comprehensive, dealing in depth with all aspects of this subject. But we will try to develop a comprehensive framework for the formulation and implementation of technology policies and plans, highlighting some aspects, and going into some detail in a small number of selected subject areas.

We will also try to build, to the greatest extent possible, on what has already been said and discussed in these sessions. If we follow the logic of Hoffman's lectures, this means that we should try to relate technology policies to the strategic goals of the effective management of technology transfer and the development of indigenous technological capabilities. These twin objectives - effective transfer and indigenous development - will be the connecting thread running through the sessions on policy and planning.

Moreover, for these objectives to be realized, they have to be made operational. That is, they have to effect what people and institutions actually do in carrying out the activities related to production and investment. We are all aware that policies and plans which exist on paper alone, are simply not worth the paper they are written on. One of the (controversial) views that we shall be advancing is that it might be better to have an impact on a small area - a project, an enterprise, an industry - in a quiet way, than to have a 'Grand Plan' which is never implemented.

This brings me to a brief aside, on the bureaucratic politics of technology policy-making.

A note on bureaucratic politics

In most of the countries that you come from, explicit technology policy is not practised. The problem is not merely the physical absence of written policies. It is rather a lack of awareness of the importance of explicit policies for technology transfer and development. Industrial policy, education policy, taxation policy - one does not have to argue for the necessity of these; they are taken for granted. But the chances are that when a technocrat brings up the subject of technology policy, he/she will encounter the MEGO[1] reaction. This lack of awareness is generalized: it exists at the highest levels of political authority, within the bureaucracy, and amongst the public at large.

Part of the reason for this is plain unfamiliarity: technology is, for many small countries with weak and overworked bureaucracies, a new subject. Often it is regarded as the province of scientists and engineers, and not of officials and politicians who are usually schooled in the liberal arts, law and the social sciences (and sometimes the military sciences!).

Apart from unfamiliarity, there are several factors which strongly reinforce the indifference to technology matters in public decision-making. Probably the most important is the desperate economic plight in which so many of our countries presently find themselves; marked by food shortages and even famine, scarcities of imported goods, manufacturing industries in collapse, swelling populations, unemployment, and so on. It is difficult to concentrate the mind on long-term questions such as technology, when crisis management of the foreign exchange situation and the fiscal accounts absorbs all the attention of the government, and when frenetic preparations have to be made for the up-coming negotiations with the IMF and the visiting World Bank mission.

You may find yourself in the position of the lonely and isolated bureaucrat. You have no allies in the bureaucracy, or at least none that you know of, who are willing to push for conscious consideration of the technological aspects of investment decisions, and deliberate attention to the building of local capabilities. There is no constituency within the bureaucracy, or in the wider economy (private sector or state enterprises) exerting pressure on the centres of decision-making to this end. The conditions just do not exist for these issues to be dealt with. Frustration and demoralization can easily be the result.

Some preliminary considerations

There are no easy answers to this problem; and in some situations it may not be possible to make any progress at all. But I would suggest that the task might be made easier if the following considerations are taken into account in devising a strategy for the initiation of explicit technology policies.

First, a common mistake is to believe that it is necessary to have "ideal" conditions in order to initiate technology policy and planning:

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[1] MEGO = "My eyes glaze over" (while my mind switches to something else).

i.e. a wholly committed Government, bureaucracy, productive sector, and general public. This is naive and unrealistic. Not only is it highly unlikely that you will have these conditions, but in fact if they did exist, there might be no need to initiate technology policies at all, as they would probably be in operation already. If you operate on this assumption, you will be certain to end up frustrated.

Second, and because of the above, it may be better to have micro-level policies than no policies at all. I would argue, for instance, that it is better to have one ministry of Government committed to a conscious technology policy in the sector for which it is responsible, than no ministries at all; for this might result in an experience that can eventually be applied by other ministries. Similarly, if even one producing enterprise can be motivated to engage in thorough preparation and search for an imported technology, the demonstration effect of any savings in costs that this brings about could have an impact on other enterprises. And a successful experience of unpackaging one Government project could be a more effective argument for a general policy of unpackaging, than all the written memoranda in the world.

I am here making the case for active use of the principle of "demonstration effect" in technology policy. The general principle is that initial policies do not have to be comprehensive or total. They can be partial; and if they work,
they can be applied to wider areas, while if they don't work, they can be revised.

Third, a specific technology policy is more likely to receive consideration if it is related to finding solutions to a specific problem faced by decision-makers or producers. Examples of these might be shortages of imported inputs, spare parts and machinery; machinery breakdowns and maintenance problems; energy availability; low productivity and high operational costs; and limited supplies of capital for new investment. The pursuit of abstract goals related to national development appears to be a luxury that fewer and fewer developing countries can afford in today's economic environment. Hence policies have to relate to concrete problems, and they must appear to be "do-able".

Fourth, to be convincing in suggesting a technology policy, you have to be adequately prepared. You must do your homework! Collect all available information, do whatever research is necessary and feasible to support your recommendations, and present it coherently. This is necessary in recommending any new policy, of course, but since technology policy is likely to be a new and relatively unfamiliar area, it becomes even more necessary in this case.

Finally, be aware of the gaps in your information and analysis, and admit them frankly. If you are unsure of the workability of a specific policy, do more research, or try to have it adopted on a small scale and on an experimental basis, so that more knowledge of the problems involved in applying it in practice can be gained. A massive failure could set back the case for technology policy for years (and could also have unpleasant personal consequences!).

Let us turn to a general overview of the issues involved in the formulation and implementation of technology policies. I will discuss these in five main categories:

- i) levels of technology policy and the "workability test"
- ii) total, partial and strategic approaches
- iii) the "two-pronged" strategy
- iv) the two categories of policy instruments, and
- v) the relationship between research and policy.

Some of the points made in the preliminary considerations will come up again in the discussion of these issues, but in a more schematic framework. Finally, a summary of the steps involved in the formulation and implementation of technology planning and policies is outlined.

The levels of technology policy

There are various levels at which a technology policy can operate. At the highest level we would normally think of a national policy, which may even be more formally expressed as a national plan for science and technology. The objective of a national policy is to influence actions related to technology in the entire country.

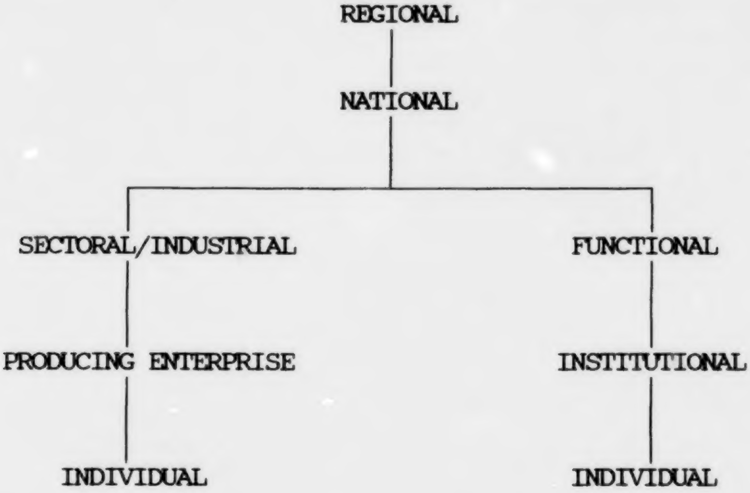
Below this is the level of sector or industry, i.e. group of producers engaged in similar activities or the production of similar products. A sectoral technology policy aims at achieving certain technological objectives for one particular sub-set of producing activities, which may be characterized by similar production techniques, and/or similar technological problems.

The next level is that of the producing enterprise. This is vital, not only because enterprises should ideally have conscious technology policies of their own, but also because technology policies at the sectoral and national levels cannot actually be implemented unless they affect the actions of individual producing enterprises in the economy. Remember too, that the "producing enterprise" can mean anything from a highly developed capitalist organization, to an individual operator in the informal sector, or a peasant farmer.

Finally, there is the level of the individual, be it unskilled or skilled worker, technician, engineer, research scientist, manager, etc., within the producing enterprise. Ultimately, technology policies depend for their success on the commitment and the activities of individuals, acting in their various economic roles, and usually (though not always) grouped into producing organizations along the lines of co-operative effort.

There are two other levels of policy that can be distinguished, and that cut across the sectoral and enterprise levels. The first of these is the functional. This is the level that applies to all national activities relating to a particular functional area, such as the supply of technological manpower, research and development, and the control of technological imports. Below the functional is the institutional. This relates to the activities of specific institutions that carry out functional policies, such as technical colleges, national science councils, and registries of technology contracts.

Figure 1. **The levels of technology policy**



Functional policies cannot be carried out unless the activities of institutions and individuals working within them, are affected; just as sectoral policies require the activities of enterprises and their staff for them to be implemented. So that it is useful to apply a "workability test" to every national, sectoral or functional technology policy. This consists of a simple question: how far will this policy influence or modify the actual technological behaviour and activities of the enterprises and institutions that it aims at affecting, as well as the behaviour and activities of the individuals working in them?

A diagrammatic relationship between the various levels of technology policy is set out in Figure 1 on previous page. It will be noted that a further level, the regional, has been placed above the national level. This applies where a country belongs to some regional grouping, such as ECOWAS or CARICOM, which is pursuing or hoping to pursue, some technological activities at the regional level. Examples of these are a common regional regime for the transfer of technology, and cooperation in R&D.

Total, partial and strategic approaches

The total approach to technology policy is the ideal one, to be adopted where all the conditions are propitious. The characteristics of the total approach may be said to be:

- it is comprehensive in that it addresses all sectors of the economy and all functional areas in the society; and does so in an integrated, internally consistent, and coherent manner;

- technology policy is consistent with all other aspects of economic and social development policy; and,

- the national technology policy/plan is supported by an effective national commitment to its objectives, and its activities, from the highest levels of political authority; and is understood and supported by the crucial sectors of the bureaucracy: the productive sector (private and public), and the wider society.

However, as we noted earlier, these conditions may not exist in many of the countries where technology policy is being tried out for the first time. The total approach actually corresponds to the conditions of the developed countries, and the more advanced of the developing countries, such as India for example. Of course, there is no reason for it not be adopted in any developing country, provided the political commitment exists and the other conditions are present. But in the absence of these, we have suggested that a less ambitious kind of approach may be tried.

This may be called the partial approach. Its main characteristics are:

- it addresses one sector of functional area at a time, or even one specific enterprise or institution, or even in an extreme case, one particular individual;

- it seeks to use the results of one technology policy event as a basis for improving subsequent policies, applying policies to a wider area, and building support for more total policies; and,

- it uses conflicts and incompatibilities, caused by the fact that the policies are not total and therefore may not be consistent with other policies, in a creative and constructive manner, i.e. as an opportunity for more general application.

As a result, it may be found that the partial approach is more feasible and manageable in the conditions of many of the smaller and less developed developing countries at this time. But if it is attempted, it is important for the partial approach not to be static, as suggested above, but to adopt a dynamic perspective whereby it can be adopted more generally. If used in a systematic way over an extended period of time, the partial approach can become a strategic approach to technology policy.

The main characteristics of the strategic approach are:

- it is informed by a sense of a feasible sequence of sets of technological activities through time (e.g. transfer, assimilation and innovation), each set providing inputs into subsequent activities;
- each set of activities is linked to a specific industry, enterprise or project where there are substantial opportunities for learning and capability development;
- the choice of sets of activities and productive operations to which they will be linked, is determined by (a) the importance of the productive activity to the national economy or the development strategy, and (b) the amount of benefits, direct and indirect, that successful performance of technological activities in that operation can yield to other industries, enterprises or projects; and,
- the objective is that the degree of technological activities and the extent of their "spread effects" or externalities, will grow with each successive set of activities in the sequence through time, as each one benefits from all the previous ones.

As may be seen, the ultimate objective of the strategic approach is to bring the country to the point where the total approach can be adopted, because all the conditions have been established and the country is well-set on the path to dynamic technological development. The important thing, however, is that progress is registered in a dynamic way, that some technological activities are undertaken that yield pay-offs and pave the way for subsequent rounds of activities.

The "two-pronged" strategy

The two-pronged technology strategy is aimed at acting simultaneously on inflows of foreign technology, and on the development of local technology. It assumes that key industries, enterprises or institutions have been targeted for intervention, as a result of using the principles of the partial or strategic approach.

The two 'prongs' of the strategy consist of (i) controlled technology transfer from abroad, and (ii) selective development of local technologies capabilities; in the targeted areas.

Controlled technology transfer involves to a large extent the issues dealt with in the presentations by Hoffman. The need for active participation in the management of the transfer process exists at all its stages, viz.

- search and selection
- negotiation, bargaining and acquisition
- project execution
- assimilation
- diffusion

Active participation in these activities can be expected to give rise to better technology choice, cheaper technology imports, and more effective assimilation and diffusion of imported techniques. It should give rise to dynamic learning effects as it is carried through a sequence of successive activities. Hence it is ultimately supportive of the development of local capabilities.

Selective development of local technological capabilities also has a number of aspects, mainly:

- in-plant innovation based on operational experience
- formal research and development
    - (a) within enterprises
    - (b) in R&D institutions
- engineering services
- capital goods manufacture
- diffusion mechanisms
- information mechanisms

Selectivity implies that, in the areas targeted for policy intervention, a start is made with those capabilities that are easiest to develop in the first instance, that are within the reach of the enterprises and institutions concerned, and that are likely to have large pay-offs. For example, innovation does not have to begin with formal R&D; it can be initiated by encouraging creative modification of existing techniques within enterprises, and the systematic evaluation of operational experience. Similarly, capital goods manufacture may grow out of repair and maintenance activities within industrial firms. Capability development implies a sequence of progression over time to activities of greater difficulty and technological complexity.

Evidently, as local capabilities develop, imported technology is gradually replaced by local technology. In addition to this, the technology that is imported can be more effectively absorbed. So that local capability development is both a consequence of, and a contribution to, effective transfer from abroad. The two prongs of the strategy are, or should be, mutually supporting.

The two categories of policy instruments

Technology policy instruments are actions, measures etc. taken by the state aimed at influencing the utilization of imported technology, and the generation and diffusion of local technology. We divide policy instruments into two categories: those operating on the demand side, and those operating on the supply side, of technology transactions.

Demand side instruments consist of measures impacting on the demand of producing enterprises and investing units, for local and imported technology (good and services). An example might be the registration and approval of contracts for the purchase of imported technology, aimed at regulating the terms and conditions of contractual technology transfer. Another might be government restrictions on imports of certain kinds of engineering services, where such services have been designated for selective local development.

Supply side instruments are those measures aimed at affecting the volume and range of the availability of local and imported technology (goods and services), as well as the terms on which it is made available. Examples are the establishment of information services aimed at making knowledge of the availability of imported technology more accessible to local users; and the establishment of R&D laboratories for the development of local techniques and to perform services for producing enterprises.

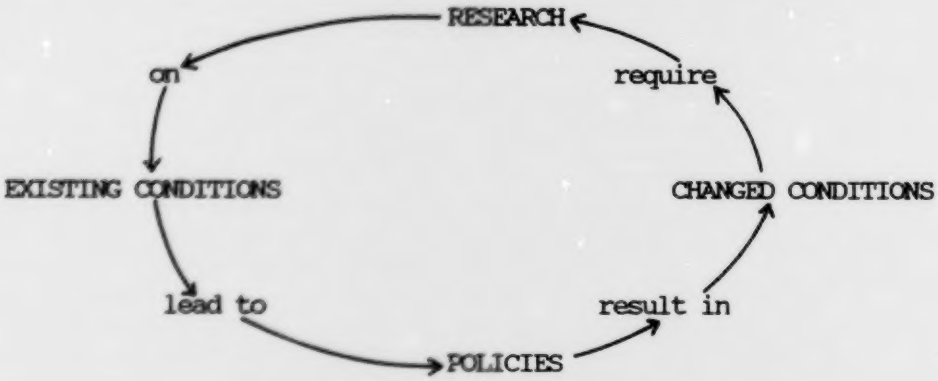
Technology policy instruments are the means by which a Government puts a specific technology strategy into effect. In the case of the two-pronged strategy discussed above, a policy instrument may be used to facilitate better search and selection of imported technology by local users, another to strengthen the hands of local enterprises in bargaining with foreign suppliers, and another for the selective development of local technology.

Relationship between research and policy

Policies imply conscious actions aimed at changing reality. If a policy is to have any chance of success at all, then it has to be based on as thorough as possible a knowledge and understanding of the reality it is meant to change. Knowledge implies the need for information, while understanding implies the need for analy- sis of information. Research for the collection and analysis of information should therefore be regarded as intrinsic element of the policy-making process, and not merely a luxury which can be afforded on some occasions, and dispensed with on others.

Research is also necessary for the evaluation of the results of policy. No matter how effective a policy is in practice, in no case will the result be actually as expected or desired. A specific policy may be highly or moderately successful, or only of limited success. It can be an outright failure, in that it has no impact whatever on the reality it is supposed to change; and it can be a disaster, by having effects which are precisely the opposite of what was intended. In all cases, it will have side effects and repercussions that were not anticipated. Hence, a process of monitoring, feed-back and evaluation

Figure 2. Relationship between research and policy



has to be built into the implementation of specific policies. Figure 2 on the previous page depicts diagrammatically this "ideal" relationship between research and policy.

Unfortunately, we are accustomed to thinking of research only in terms of formal research projects of a fairly substantial nature, carried out in universities and specialized research organizations. Often this means that when it is not feasible to carry out this kind of research on a specific policy or policies, nothing is done at all. One should bear in mind that any activity that gives rise to usable information, and upon which analysis and conclusions can be based, can be regarded as research. A visit to an industrial enterprise, an interview with plant manager or industrial worker, a small-scale survey, are all examples of relatively modest activities which can yield information helpful to the formulation and evaluation of technology policy.

Three stages and eight steps in national technology planning and policy-making

We can wind up this introduction and overview by summarizing what we think are the main steps which the responsible official(s) and organization(s) would need to undertake in order to prepare a technology plan, or technology policies. This could apply at any of the levels indicated, from regional down to individual. In practice it is likely to be used mostly at the national level, and at the level of a particular industry, and a specific functional area.

We distinguish three stages, namely:

I the preparatory stage; i.e. the collection and analysis of information on initial conditions, and the specification of development objectives;

II the formulation stage; i.e. the identification of areas for policy intervention, and of specific policy instruments; and,

III the implementation stage; i.e. the carrying out of policies, and their continuous modification as a result of feedback.

Each stage can be broken down into a number of discrete steps, representing the activities that will need to be undertaken, as follows:

I **Preparatory stage**	1.	Economic mapping
	2.	Technology mapping
	3.	Analysis of implications of development objectives
II **Formulation stage**	4.	Selection of areas of policy intervention
	5.	Selection of policies and policy instruments
III **Implementation stage**	6.	Establishment of policy instruments
	7.	Monitoring and feedback
	8.	Modification of policies and introduction of new policies

This is a convenient point at which to wind up our overview. The next presentation is devoted entirely to a discussion of the research tasks involved in the preparatory stage of national technology policies and planning.

NATIONAL TECHNOLOGY POLICIES AND PLANNING

2-THE PREPARATORY STAGE: RESEARCH TASKS IN TECHNOLOGY PLANNING AND POLICIES

Introduction

From here on we will be assuming that there is an intention on the part of a Government or governmental body to introduce explicit technology policies. We need to set out as clearly as possible the kinds of activities that the officials and bodies responsible for this subject, would need to undertake in order to develop and implement such policies. We have distinguished three stages in this process: preparatory, formulation, and implemen- tation, indicating that a number of steps will need to be undertaken within each stage.

This presentation discusses the steps to be carried out in the preparatory stage. All of these activities involve the conduct of research of one kind or another. Hence, an alternative name for the presentation on the preparatory stage could be "research tasks for technology policy formulation".

Steps in the Preparatory Stage

In the previous presentation we emphasized the need for thorough preparation, especially when technology policies are being introduced for the first time. Information needs to be collected, and analyzed, on the "initial conditions" that the policies are meant to change. What information is needed will depend on the particular area that the policies are intended to affect. If the objective is to improve the techniques in use in agro-industry, then a survey of that industry will probably be called for; or if it is felt that contractual technology transfer should be regulated, an analysis of the contracts in force may be found to be necessary.

More generally, the steps which are necessary in the preparatory stage may be grouped conveniently as follows:

1. economic mapping
2. technology mapping
3. analysis of the implications of development objectives

Each of the steps can be used to develop a "checklist" of research activities to be carried out to generate the required information.

Step 1: Economic Mapping

This derives from the need for basic information on the nature of the economic activities to which technology is related in the country in question. Two kinds of information are required. First, information on the structure, volume and value of productive activity. Normally this will be presented as production data — physical and value — grouped by sector and by industry. It is this productive activity which defines the underlying demand for production technology generated by the economy.

Second, there is need to find out the ownership and organization of productive activity within each sector and industry. There are several distinctions that are relevant here. One is the basic distinction between state and private enterprises. Within the private sector, there are foreign-owned (transnational) firms, local private firms, and joint ventures between foreign and local firms (there are also joint ventures between state and private firms, whether local or foreign). The local private sector itself includes "public enterprises", in the sense that their stock is traded on the stock exchange and their annual reports are published, and private or family-owned firms. A distinction should also be made according to size, i.e. large-scale and small scale-producers, and sometimes intermediate as well. Finally, there is an important distinction to be made between the formal and the informal sector.

The importance of identifying the ownership and organization of productive activity is that it defines the socio-economic context within which production technology is applied. As we stress in a later section of this presentation, technological decision-making by an enterprise is often very strongly affected by the nature of its ownership and organization. For example, small scale/informal producers often use quite different techniques of production from those used by large-scale/formal enterprises in the same industry. By the same token, they may respond quite differently to the same policy; and policies may therefore have to differentiate between different categories of enterprises in the same industry.

Step 2: Technology Mapping

The purpose of this step is to build up a technological picture of the industry or industries concerned. The main technological features relevant to the formulation and implementation of policies should be identified. These are almost certainly going to include:

- characteristics of the production technology in use;
- assessment of relevant international trends in technology;
- forms of technology flows and transactions, including identity of main suppliers and users; and,
- assessment of local technological capabilities.

The first task above is to describe and characterize the production technology used in the productive activities in question. Here it is necessary to avoid a simple bi-dimensional "economistic" classification, such as ratios of labour and capital to output. Other economic characteristics of the technology are also important, such as scale of production, requirements for skilled and unskilled labour, input cost structures, management requirements, and nature of the product. In addition, the engineering and scientific characteristics of the production technology are as important as the economic aspects as far as the needs of policy-making are concerned. Hence, accurate characterization of the technology in use will be a multidisciplinary exercise, requiring inputs from economists, scientists and engineers. Ideally, these should be operating together, on a teamwork basis, so that the benefits of disciplinary interaction can be derived. We have seen the benefits of such multidisciplinary teams in the research projects undertaken in the Workshops.

The second task is to carry out an assessment of the international trends in technical change that are likely to impact on the industry/industries and (if this is a national technology planning exercise) on the whole economy. For this, it will be necessary to collect information on the technologies in use in similar activities abroad, the "frontier" technologies being introduced in new investments, the trend in foreign R&D activity, and projections or at least qualitative opinions about the likely trend in technical change.

The third task of technology mapping is to identify the flows of technology and the nature of technology transactions in the productive activity. To do this, it will be necessary to employ a typology in which the forms and mechanisms of these flows/transactions are differentiated. The typology will probably include the list contained in Table 1 on the next page, which is not necessarily exhaustive.

It will be necessary at the same time also to identify the principal types of suppliers and users involved in each form of technology flow. For example on the supplier side one will find transnational corporations engaged in agriculture, mining, industry or services; international and domestic engineering consultancy firms; multilateral and bilateral development agencies; foreign and local R&D institutes, foreign and local machinery supplies, and so on. The broad distinction between foreign and local sources of technology is obviously very important here. Among the users, the relevant categories are the same as those for the ownership and organizations of productive activity in step (1) above, i.e. local subsidiaries of TNCs, state and private firms, informal sector producers, etc.

Table 1. Technology Mapping: forms and mechanisms of technology flows

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(i) foreign direct investment (combining capital goods, patented knowledge, unpatented know-how, management, and marketing)

(ii) licensing agreements (for the use of patents, brand names, trade marks, and other proprietary knowledge)

(iii) technical assistance and technical service contracts

(iv) management contracts

(v) marketing contracts

(vi) provision of engineering and consultancy services, feasibility studies, and other services for pre-investment and investment work

(vii) turnkey contracts

(viii) sale/purchase of capital goods

(ix) research and development activities

The fourth and final task of technology mapping is to make an inventory of stocks of local technological capabilities which are available locally. Quantifying capabilities is tricky, since so much of it is in the form of skills and accumulated experience, and embodied in personnel and institutions. Hence, one should never be satisfied with the results of statistical surveys based on questionnaires as providing a complete picture of capabilities. These will have to be supplemented by qualitative assessments of the kind that can be made through direct interaction with producing enterprises and technology institutions.

A good place to start is with the capabilities present within producing enterprises themselves, since these are so frequently overlooked. For each industry concerned, it will be necessary to develop a method of evaluating the level attained in the development of the relevant technological capabilities amongst its enterprises, and of the critical resources needed for filling in its capability "gaps" and needs for further development of its capabilities. For ideas on an assessment methodology, reference may be made to the lecture on "technological capability"[2] and to the work by Farrell[3] on the petroleum industry.

Next, it will be necessary to survey the organizations providing flows of technological personnel, goods and services to the producing enterprises. Many of these should already have been identified from the list of local sources of technology supplies developed as a result of prior technology mapping. This will include R&D institutes, machine shops fabricating or repairing machinery and equipment, and engineering consultancy firms. It may also be necessary to include technical training and profes- sional educational schools, depending on the specific purposes that the policy under consideration is expected to serve.

A listing of the main institutions to be covered in an assessment of technological capability is provided below in Table 2.

Table 2. Technology Mapping: institutions to be included in assessing technological capability

(i)	producing enterprises
(ii)	research and development organizations
(iii)	machine shops/capital goods producers
(iv)	engineering consultancy firms
(v)	technical and professional training schools
(vi)	information system and mechanisms

As a result of the work undertaken on technology mapping, one should have developed the kind of technological picture necessary for the formulation of policies aimed at controlling technology imports and selectively developing local capabilities. But there is one more step which needs to be taken before the preparatory stage is complete.

Step 3: Consideration of the implications of the national development strategy

A technology strategy or policies cannot be developed in a vacuum. It must relate to the broader objectives of the country, the Government of the country, and the institutions and producing enterprises that create and use technology. Hence, the final step in the preparatory stage is a consideration of the implications of the national development strategy.

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[2] Norman Girvan, Working Notes on Technological Capability, St. Augustine, Trinidad: CTPS II Working Paper No. 1, 1982.

[3] Trevor Farrell, "Nationalization of the Oil Industry in Trinidad: A Tale of Two Issues", Social and Economic Studies, March 1979.

By a national development strategy we mean:

(a) an articulation of broad objectives for economic and social development;

(b) a statement, which may be more or less specific, of the growth path it is intended to pursue in order to attain these objectives; and,

(c) a specification of a coherent set of policies which will be adopted by the Government to realize the growth path and attain the objectives.

The growth path is of special interest, since it will indicate which industries are expected to lead the growth process. It is in the leading industries that new investments and projects will be concentrated, and which will therefore provide opportunities for technological learning through participation in preinvestment and investment activities, and in efforts at assimilation of imported techniques.

The growth path will also indicate the market orientation of the leading industries and the economy as a whole, and especially the relative reliance to be placed on production for the export market vis-a-vis production for the domestic market. This is the issue of "export-led growth" vs. "import-substituting industria- lization". Export-oriented industries will be exposed to the pressures of international competition, and will have a take this into account in deciding on their choice of technology. Industries producing for a protected domestic market may on the other hand enjoy the benefits of an extended period of insula- tion from foreign competition, giving them the opportunity to organize themselves to take advantage of dynamic learning effects.

The growth path and the policy framework can also be expected to indicate the role of the state, and the relative importance of the public and private sectors in the development strategy. A strong role of the state and of public enterprises can be characterized as "state-led economic growth". Most of the incremental demand for production technology will be generated by state enterprises and government institutions. Technology policy will need to affect the decisions of these enterprises, probably through the central planning mechanisms and the procedures for the regulation and approval of public investments. Where the private sector plays the predominant role, technology policies, like other economic policies, will need to place strong reliance on market mechanisms combined with some regulation.

A development strategy may or may not be published formally as a National Development Plan. A Development Plan will normally contain:

(a) a statement of the Government's long-term strategy for the economy;

(b) projections of economic growth and the main macro-economic parameters over the Plan period, usually five years;

(c) a public investment programme with a list of the main projects to be undertaken by the Central Government and the state enterprises over the Plan period; and,

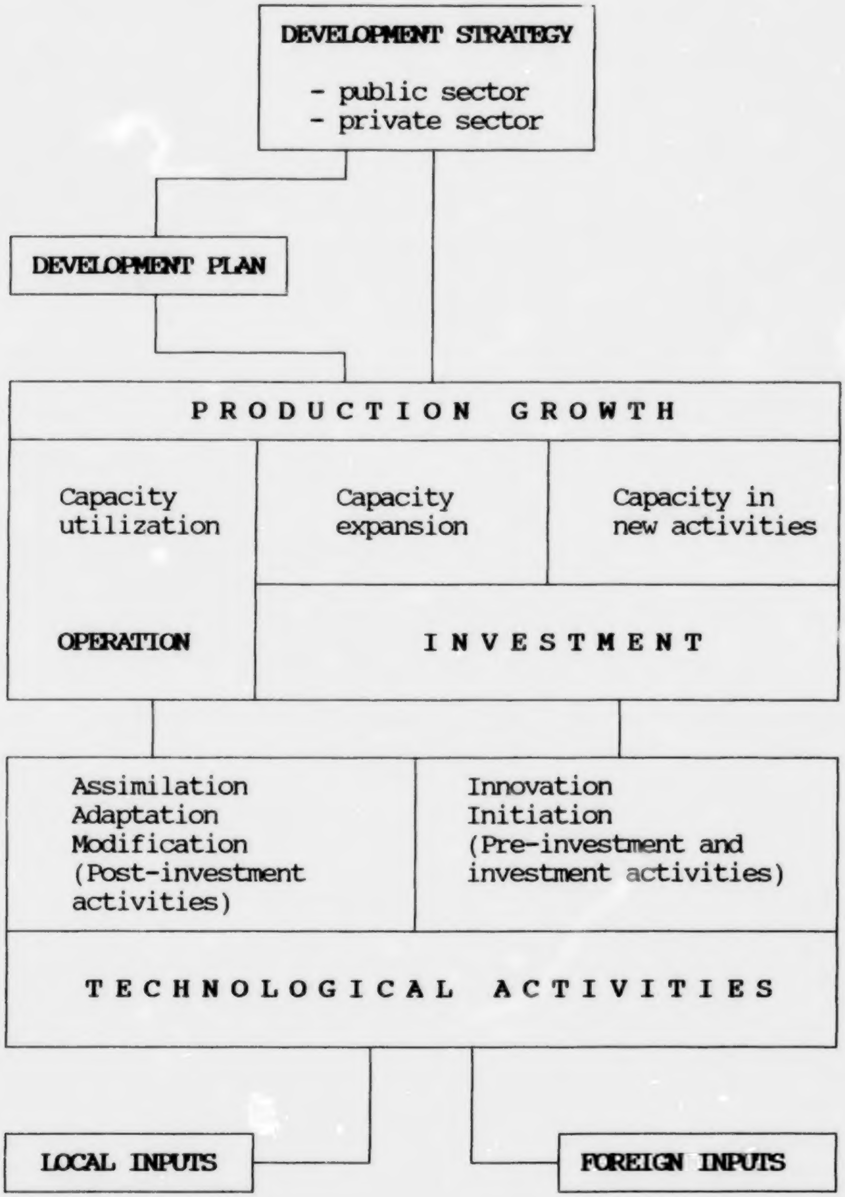
(d) a statement of policies which will be used to influence the private sector in support of the main economic targets over the Plan period.

A Development Plan, where available, is a useful source of information on productive activity and growth points in the economy, which require the use of technological inputs. In the absence of a formal Development Plan, the same kind of information can often be obtained from a variety of sources: expansion plans of state and private enterprises, investment intention surveys, Government programmes of investment in economic and social infrastructure, and Government's economic policies. This is the kind of information which will indicate the areas of productive activity and investment where it may be possible to take advantage of opportunities for technological learning, through the controlled use of foreign technology and the selective development of local capabilities.

The relationship of technological inputs to the Development Strategy/Plan is shown diagrammatically in Figure 1. The development process can be translated into production growth of specific industries. Production growth is derived from (a) more efficient utilization of existing installed capacity, and (b) expansion of capacity in existing and new activities through investment. More efficient capacity utilization requires technological efforts in assimilation, adaptation and modification of techniques -- the issues discussed by Hoffman in the "post-investment stage". The investment process requires the development of technological capabilities for search, selection and acquisition of technology -- the activities discussed by Hoffman in the "pre-investment and investment" stages. If local technology is to be incorporated into production via investment, this will require the generation of indigenous innovations, both as a result of operational experience in production and from formal R&D.

The relationship between the development strategy and technology policy is also iterative. For example, as a result of assessing international technology trends, the technology planners may recommend that certain export activities should be de-emphasized, or that certain investments should be modified to take account of the impact of technical change. Or as a result of reviewing the technological

Figure 1. **Relationship of technological inputs to the national development strategy or plan**


DEVELOPMENT STRATEGY
- public sector
- private sector
DEVELOPMENT PLAN
PRODUCTION GROWTH
Capacity utilization
Capacity expansion
Capacity in new activities
OPERATION
INVESTMENT
Assimilation
Adaptation
Modification
(Post-investment activities)
Innovation
Initiation
(Pre-investment and investment activities)
TECHNOLOGICAL ACTIVITIES
LOCAL INPUTS
FOREIGN INPUTS

requirements of new public and private investments, the technology planners may recommend Government support for certain technological services, such as engineering or information. This will become clearer when we discuss technology policy instruments in greater detail.

It may be useful to refer to the actual experiences of developing countries as regards the relationship between development plans and technology planning. Some countries have in fact succeeded in bringing about a fairly close integration of the two: among the most interesting examples of these are India, Brazil and the Republic of Korea. In other cases development planning and technology planning have proceeded independently, without any clear connection, and sometimes with inconsistencies between the two. Reference may be made to the summaries of the experiences of the above three countries, as well as Argentina, Colombia, Egypt, Mexico and Venezuela, in the main report on the STPI project.[4]

Conclusion

Let us now review the research tasks involved in the preparatory stage. This may be set out in the form of a "checklist", which is done in Table 3 below.

Table 3. Research tasks in preparing national technology policies or planning

A. Economic mapping

1. Production data: volume and value by sector, industry, and product group
2. Data on ownership and organization of production

B. Technology mapping

1. Characteristics of production technology is use
2. Assessment of international technology trends
3. Technology flows and transactions: forms and mechanisms, including identification of main suppliers and users by tape
4. Assessment of local technological capabilities

C. Consideration of national development strategy or plan

1. Broad socio-economic objectives
2. Identification of growth industries
3. Market orientation
4. Relative importance of public and private sectors and foreign capital
5. Major investment projects in the public sector
6. Investment intentions of the private sector
7. Principal Government policy instruments for development

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[4] Main comparative reports of the STPI project. IDRC-109E; p. 64.

This concludes our discussion of the preparatory stage in technology planning and policy-making. Armed - hopefully - with a wealth of information, it should be possible to proceed to the next stage, that of formulation of specific plans and policies.

NATIONAL TECHNOLOGY POLICIES AND PLANNING

3-THE FORMULATION STAGE: THE SELECTION OF AREAS AND POLICY INSTRUMENTS

Introduction

Once the preparatory work is completed, the next stage in the policy process is that of formulation. The work of formulation can be broken down into two discrete steps:

1. selection of areas for policy intervention; and,
2. identification of policies and policy instruments.

1. Selection of areas for policy intervention

This is the process by which certain conscious decisions are taken to concentrate technological efforts in particular industries and functional areas. The need for this has been discussed in arguing the merits for a partial and strategic approach to technology policy-making. But even where a country adopts a total approach, it will be found that there is a need to decide on priorities for such things as investment in research and development, and expenditures on technological imports.

Hence, a key input in this decision-making process will be the elaboration of rational selection criteria for policy intervention, criteria which reflect the objectives of development and of the technological strategy. The general criterion will be that the policies should have a high benefit/cost ratio. But in developing countries without a tradition of policies, we have suggested that it may be necessary to start in a small way, and to limit efforts to areas which produce a visible demonstration effect. Using the principles of the partial and strategic approaches, criteria may be suggested for the selection of areas for policy intervention:

(i) Direct profitability: high ratio of expected benefits to costs in the activity itself. This provides an incentive to decision-makers directly involved in it.

(ii) Modest, or at least affordable, requirements of scarce technological manpower, money, and foreign exchange. This improves the chances of adoption in an environment where resources are limited and decision-makers are averse to taking major risks.

(iii) Utilises a minimum quantum of locally available resources, especially human resources. This not only makes economic sense, but also facilitates the building of constituencies of support for technology policies.

(iv) Externalities: expected spin-offs and benefits to other areas are high. This demonstrates the wider "national" significance of technological effort.

(v) Technology is a critical constraint to successful operation of the activity. This highlights the visibility of the technological factor.

(vi) The policy intervention should have a high probability of success.

(vii) Finally, if possible the anticipated benefits should be such as to have political appeal to the ruling group. This should normally follow from the satisfaction of the other criteria.

The criteria may be modified according to the specific circumstances faced. They will then need to be applied to the information already gathered as a result of preparatory research. The purpose is to identify specific industries, and functional activities, where technological effort will be concentrated. It is these industries and activities which will be the target areas for policy intervention; that is, targets for the control over technological imports and the selective development of local capabilities.

To show how such a selection process might work, we provide below two examples of hypothetical technology planning taken from a recent UNCTAD publication. While the steps used in arriving at the selection are not identical to those suggested above, they are sufficiently similar to be used as an illustration.

> Country X This is a medium-sized, middle-income, semi-industrialized, copper-exporting country. The population is 35 million and the per capita GNP is $600. Manufacturing accounts for 20 percent of the GDP, copper mining 10 percent and one-third of exports. The Government majority ownership of mining, but other industry is mainly privately owned, and there is substantial foreign private investment. The main sectoral objectives of Development Plan are (a) additional processing of copper, (b) improve competitivity of the industrial sector, particularly processed food, timber, and rubber manufacturers, (c) lay foundations of capital goods industry, particularly machinery, and (d) continue the diversification of agriculture through further specialization and modernization.
>
> The short-term technology plan of Country X will aim at: (i) improvement in the yields of palm, palm-oil and rubber, (ii) adaptation of imported technology in the footwear, protective

clothing and tyre industries with a view to raising productivity, (iii) further adaptation of techniques of drying, curing, refrigeration and canning of fish, in order to improve exploitation of fishing resources, and (iv) execution of adaptive R&D projects on the equipment required for the industries above, e.g. edible oil extraction, footwear, timber (saw milling machinery), fish processing and storage, agriculture (pumps).

The *medium-term* technology plan will provide for: (i) a training programme to provide technological manpower for the mining industry in surveying for new deposits; planning, designing and managing new mining projects; and progressively undertaking further processing of copper and the manufacture of final products, and (ii) continuation and expansion of (iv) above.

Country Y This is a relatively small, low-income, non-industrialized country. The population is 15 million, the per capita GNP $300, and manufacturing is only 10 percent of the GDP. Industry is mainly privately owned, with many joint ventures between local and foreign investors. The economy is largely agricul- tural. Main sectoral objectives of the Development Plan are (a) to harness water power through hydro- electric projects, (b) continued modernization and development of agriculture, (c) expansion of manufacturing by raising productivity of existing resource-based industries, and putting more emphasis on intermediate and capital goods, and (d) reducing regional inequalities by spreading industrial and agricultural production geographically.

The *short-term* technology plan of Country Y will aim at: (i) establishing a system for the effective screening of imported technology and linking the various elements of an integrated policy for the transfer and development of technology, (ii) executing a large-scale project for acquiring mastery of the techniques of water management, (iii) setting up of a new agency responsible for the design, engineering and management of major power and irrigation water supply projects, with built-in training and research arrangements through external assistance, in-house training, and selected fellowships abroad, and (iv) execution of R&D projects for the design and partial manufacture of: pumps, irrigation gates and control equipment, medium-scale electric motors, small tractors and agricultural implements, high-pressure vessels and pipes, automotive parts, textile machinery.

The *long-term* technology plan will extend the above into: (i) broadening the range of hydropower equipment to be designed, adapted and developed domestically, and (ii) design and development of a range of food-processing equipment, notably for legume, fruit and vegetable processing, baking, and the preparation of meat, fish, eggs and poultry, including utilization of by-products[5].

2. The selection of policy instruments

(i) The need for consistency

The next step is the selection of the specific instruments through which the technology policies and plans will be carried out. Let us first of all review what technology policy instruments are available. In the last presentation we said that, generally, technology policy instruments may be divided into those which operate on the demand side and those which operate on the supply side. The former are measures that affect the demand for foreign and local technological inputs by local uses of technology; while the latter are measures that affect the volume, range and terms of the availability of local and imported technology.

Demand side policy instruments should be selected with the aim of providing a framework for the efficient selection, acquisition and assimilation of imported technology, and deflecting demand towards available local sources of technology, in the selected industries. Simultaneously, supply side instruments should be selected with the aim of improving the accessibility and cheapening the cost of imported technology, while increasing the availability of local technological resources, in the same industries.

The package of policy instruments deployed should therefore be mutually supporting and consistent. And this applies not only to the mix of demand side and supply side instruments, but also to the relationship between explicit and implicit policy instruments. Explicit policies are those that are consciously directed at affecting the technological behaviour of enterprises and the supply of technological resources. Implicit policies, on the other hand, are directed at other objectives, but have indirect effects on technological conditions. Since implicit policies are contained in other aspects of economic policy — such as foreign investment policy and industrial development policy — it is important to take these into account, and to apply consistency tests to ensure maximum compatibility in the entire set of policies as a whole. Table 1 below, which lists the main demand side and supply side policy instruments, also distinguishes the implicit from the explicit instruments.

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[5] For further details of these two examples, and for examples of technology planning for four other hypothetical countries, consult the UNCTAD publication Planning the technological transformation of developing countries (New York, United Nations, 1981) chapter VIII. The examples above are summaries of Countries C and E given in that chapter.

Table 1. Demand side and supply side technology policy instruments

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1. **DEMAND SIDE**

   A. Explicit

      (i) Regulations of contractual arrangements for technology transfer
      (ii) Policies of technology procurement of Government and state enterprises

   B. Implicit

      (i) Industrial development policy
      (ii) Import controls: goods
      (iii) Import controls: services
      (iv) Tariff policies
      (v) Incentive policies
      (vi) Foreign investment policy
      (vii) Consumption policy

2. **SUPPLY SIDE**

   A. Explicit

      (i) Government investment in research and development
      (ii) Development of technological capabilities within state enterprises
      (iii) Government subsidies to, and incentives for, development of private enterprises' technological capabilities
      (iv) Education of technological manpower

   B. Explicit/implicit

      (i) Support for the engineering sector
      (ii) Support for the capital goods sector
      (iii) Information mechanisms

(ii) Relationship between policy instruments and decision-making at the enterprise level

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A major concern of technology policy is to influence enterprises and investing units to make adequate preparations in the pre-investment stage for the acquisition of imported technology, in order to maximize technological learning through local involvement in pre-investment and investment activities, and to optimize utilization of plant and technical change after start-up by using the D-S-P principle. To materially affect such technological behaviour, policy instruments must enter tangibly into the factors affecting decision-making at the enterprise level. There are two issues to be considered here.

The first is the blend of the "carrot" and the "stick". As a general rule, policy instruments rely either on the principle of incentive or that of regulation, or frequently on some combination of both. The first utilizes the self-interest of those affected, while the second utilizes -- ultimately -- the coercive power of the state. It is arguable that few cases can be found in the real world of a successful policy instrument that relies only on self-interest, without any coercive sanctions, or only on coercion, without any element of rewards for compliance. The trick of devising effective policies may well be to find the right combination of the two.

The second issue is the need to fashion policy instruments in the light of the objectives and motivations of specific enterprises and groups of enterprises, and the constraints under which they operate. In the previous presentation, in the section on economic mapping, we discussed the need to make distinctions between categories of enterprises according to their ownership and organization. The main categories of interest for the purpose of analyzing technological decision-making are:

(i) state-owned enterprises

(ii) foreign-owned companies, particularly local subsidiaries of transnational corporations

(iii) local large private enterprises

(iv) joint ventures: state-foreign, local private-foreign, state-local private

(v) small-scale, own-account, and informal sector enterprises

It will be found that there are wide differences between these categories of enterprises with regard to the:

- objectives and motivation of the owners and managers
- sources and availability of technology
- access to capital funds and to credit
- product type
- scale of operation
- market served

Each of these factors will affect their economic behaviour and impact on their technological decision-making. For example, in the literature it has been suggested that the objectives of each of these categories differ as set out in Table 2 below.

Table 2. Objectives of different categories of enterprises

Type of enterprise	Objectives
1. State-owned	Maximize before-tax profits, may be constrained by political objectives, e.g. deliver a basic good or service at low price, employment, etc.
2. TNC subsidiary	Maximize after-tax profits worldwide of parent firm
3. Local large private	Maximize after-tax profits nationally
4. Joint ventures	Depends on objective of participating companies
5. Family-owned	Maximize total family income and employment
6. Small-scale/ own account/ informal	Survival

Differences will also be found with respect to other factors. For example, TNC subsidiaries generally draw from their parent companies their know-how, capital goods, credit, and product type, and are to a greater or lesser degree subject to the decision-making of the head office of the corporation. TNC subsidiaries also usually cluster in certain industries and product groups: manufacturing and services catering to the domestic high-income market, and resource-based export industries. Policy instruments which may be workable in other circumstances may not be effective in influencing the behaviour of TNC subsidiaries which have to account to head offices abroad, and can evade regulations using the flexibility afforded by the transnational structure of the parent firm's operations.

In principle, locally owned enterprises should be more subject to the influence of policy instruments. For example, incentives and disincentives that impact on local profitability will not be contradicted by global profit maximization considerations. Government regulations cannot be circumvented merely by use of affiliate-head office transactions. The evidence from a number of countries -- for example India and the Republic of Korea -- shows that local enterprises have indeed been at the forefront of the unpackaging of imported technology and the development of indigenous capabilities. At the same time many instances have been found where local enterprises behave in much the same manner as affiliates of TNCs, entering into technology transfer contracts with TNC suppliers that are virtually identical to those made between affiliates and their parent companies[6]. This has often been attributed to the competitive environment in which these enterprises operate. In other words, the mere fact of local ownership does not necessarily predispose an enterprise towards a more "local" type of technological behaviour.

Much the same kind of considerations apply to the role of state-owned enterprises (SOEs). In principle, these enterprises can be powerful instruments for the development of local technological capabilities, and in a number of instances they have indeed functioned to that end. Examples of these are their role in the development of the capital goods industry in India, and the petrochemicals industry in Brazil. Yet many other instances have been found in which SOEs have entered into joint ventures and technology agreements with TNCs which render them completely dependent technologically on the latter. This can only be avoided if SOEs operate within a broader Government policy framework and guidelines which orient them explicitly towards the absorbtion and assimilation of imported technology and the development of their own technological capabilities, as conscious and specific objectives of their operation[7].

Policy instruments therefore need to be tailored very carefully to suit the circumstances of different kinds of enterprises. Some interesting illustrations of the kinds of differences that arise are provided by the case studies carried out by partici- pants in the Technology Policy Workshops, some of which are published separately. Among the most revealing cases are the following:

Tanzania

- General Tyre (EA) Ltd., a joint venture between the state (74%) and an American TNC (26%) for the manufacture of tires.
- Jandu Plumbers Ltd., a private, family-owned, metal-working enterprise.
- Sunflag Tanzania, a wholly-owned subsidiary of an Asian-owned TNC based in Kenya, engaged in textile manufacturing.

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[6] On this, see M.A. Odle, "Technology Leasing in Guyana and Trinidad", S.E.S., March, 1979; also Stephen Langdon, Multinational Corporations in the Political Economy of Kenya, chapters 3 and 4.

[7] See M.A. Odle, State-Owned Enterprises and the Development of Technological Capability. Final Report to CTPS II Project, 1984.

- Kilimanjaro Textiles Ltd., a wholly state-owned textile manufacturing enterprise.

Liberia

- LAMCO Mining Company and Bong Mining Co., both 50-50 joint ventures between the state and European and American TNCs, engaged in iron ore mining.

Jamaica

- Cornwall Dairy Development, owned jointly by the state (86.6%) and a dairy farmer's co-operative (13.4%), for the manufacture of packaged fresh milk.

- Kingston Industrial Works "Expand-a-Home" system, jointly owned by the state (49%) and private interests (51%), for the manufacture of modular housing units.

- Moxon's Community Projects Ltd., an individually owned, small-scale enterprise manufacturing building materials and furniture from locally available materials.

- Highgate Food Products Ltd., manufacturing cocoa products. It is a private, employee-owned enterprise, which took over the operations of a British-owned TNC when it withdrew from Jamaica.

- Caribbean Castings Ltd., a local enterprise engaged in the manufacture of steel castings.

Careful reading of these case studies shows the wide variety of circumstances affecting technological behaviour, and in the nature of Government policies suggested. They also show the value of conducting in-depth research by multidisciplinary teams, on specific enterprises, to help in the formulation of policy.

In winding up this discussion, it might be useful also to refer to the results of research conducted in Latin America under the leadership of the Argentine economist, Jorge Katz. The research team of economists and engineers examined the economic and technological performance, over a period of decades, of well over fifty industrial firms in six Latin American countries. After reviewing the evidence on the technological learning process in these enterprises, Katz concludes as follows:

> Perhaps the most important conclusion emerging from the present discussion is that no general statement concerning public policy in the field of protection can be made on the basis of a simplistic specification of the production function. "Taylor-made" policy actions appear to be needed that would closely reflect the specificity of the learning situation of each

particular form of production organisation[8].

While these comments apply specifically to the role of protection policy, they may apply with equal force to across-the-board policies as a whole. One such kind of across-the-board policy is the regulation of contracts for the importation of technology, discussed in presentation No. 5.

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[8] Jorge Katz, "Technological Innovation, Industrial Organisation and Comparative Advantages on Latin American Metalworking Industries", in Martin Fransman and Kenneth King (eds.). Technological Capability in the Third World. London: Macmillan, 1984, p. 135.

NATIONAL TECHNOLOGY POLICIES AND PLANNING

4-THE ROLE OF FOREIGN INVESTMENT POLICY AND INDUSTRIAL DEVELOPMENT STRATEGY

Introduction

In previous presentations we have emphasized that technology policy is, in one sense, a derivative of a country's overall development strategy, although the relationship between the two is also iterative: technology policy impacts on development. In this presentation we explore some of the implications of this relationship. The specific issues to be discussed are the implications of a country's policy on foreign investment and foreign companies, of its industrial development strategy, and of its consumption policy.

Foreign investment policy

This is the set of policies that affect the terms on which foreign direct investment is allowed entry, and the operations of foreign-owned companies within the economy. The terms of inward foreign investment refer to the industries which are open to this investment, the criteria for admitting investment, and the form permitted, i.e. wholly or majority-owned, or 50-50 or minority-owned joint ventures. Policies affecting the operations of foreign-owned and/or controlled companies in the economy include performance requirements (e.g. local procurement, import ceilings, export obligations), mergers and acquisitions policy, and taxation policies.

The relevance of foreign investment policy stems from the fact that affiliates that are majority-owned or substantially controlled by TNCs are subject to the decision-making of the parent company abroad. Decision-making is guided by the global profit-maximizing objectives of the TNC. The local affiliate is not necessarily "free" to engage in its own R&D, adapt its technology to the local market size and factor endowments, and transact with local engineering firms and research institutes. From the point of view of the parent TNC, it is usually more profitable for all its subsidiaries worldwide to use the technology that is generated in its headquarters in the home country.

A good illustration of this is provided by the results of a census of the technological activities of U.S. multinational firms carried out by the U.S. Department of Commerce for the year 1977. It was found that in that year U.S. TNCs spent the grand total of $20,670 million on Research and Development. But of that amount 89.8 percent was spent by the parent companies within the United States while only 10.2 percent was spent by foreign affiliates[9] -- although these affiliates accounted for over 28 percent of total sales! While parent firms spent $14 for every $1,000 of sales, their affiliates were allowed to spend only $4 for every $1,000 of sales. Moreover, of the 10.2 percent spent by foreign affiliates, those in other developed countries spent 9.5 percent, while those in the developing countries were responsible for just 0.7 percent. Affiliates of American TNCs in developing countries thus carry out very little R&D to speak of, and are virtually entirely dependent on their parent companies for technology.

This picture is very much corroborated by a large number of case studies on the operations of TNC affiliates/subsidiaries in developing countries, including both studies done on individual industries, and on foreign companies as a whole. A recent report prepared for the United Nations Centre of Transnational Corporations (UNCTC)[10] surveyed the results of this body of research under three main headings:

- evidence on the transfer of skills to the employed labour force by TNCs
- evidence on stimulation of local technological activities by TNCs (e.g. research and development, local capital goods)
- evidence on diffusion of new techniques throughout the economies by TNCs

In the case of skills transfer, it was found that this occurred mainly for operational activities required for production within the subsidiary companies, and often up to the level below that of senior management. How far the staffing of senior technical and managerial posts had been localized appeared to be influenced by a number of factors including how long the industry had been operating within the country, its technological complexity, the general level of educational development in the country, and the amount of pressure exerted by the host Government. Even in the most favourable of circumstances, however, there appeared to be a TNC policy to reserve at least a small number of the most sensitive managerial and technical positions for appointees from the head office. The overall conclusion was that specific Government policies will usually be found to be necessary in order to ensure that nationals are sufficiently exposed to learning opportunities within these firms, and a satisfactory rate of skills transfer takes place.

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[9] That is, majority owned foreign affiliates (MOFAs for short). See William K. Chung, "Technology-Related Activities of U.S. Multinational Companies", in U.S. Multinational Companies: U.S. Merchandise Trade, Worldwide Sales and Technology-Related Activities in 1977. Washington: U.S. Dept. of Commerce, Bureau of Economic Analysis, August, 1983.

[10] "Transnational Corporations and Transfer of Technology Arrangements in Selected Sectors". Report submitted by Norman P. Girvan to UNCTC, December 1984 (Mimeo).

A much less satisfactory state of affairs was found as regards the conduct of R&D locally and the stimulus provided to local technological activities. Most of the case studies reviewed found that the TNC subsidiaries carry out little R&D of consequences, beyond quality control and very minor product adaptations to the local environment, and that this is correlated with the fact of foreign ownership and dependence on the parent companies for technology. Some evidence has been found of more substantive R&D activity by particular TNC subsidiaries in Latin America, such as the cases of a rayon plant and a telecommunica- tions enterprise in Argentina reported by Teitel[11]. In those cases, the local R&D appears to have been undertaken in response to the size and the peculiarities of the local market, which not only required product adaptation but also made it profitable, and also by local procurement policies, which compelled certain adaptations to locally available inputs.

On the diffusion of new techniques to local enterprises, this was also found to be highly limited because of the very low linkage effects of a large number of TNC-dominated industries. In assembly-type industries set up for import-substitution (such as consumer appliances and pharmaceutical) and for export-processing (such as electronics and garments) very few relationships are established with local suppliers, or customer firms. Often too, the technological skill requirements for local labour in these industries are of a very low level. As a consequence the technological spin-offs arising out of these operations was found, with few exceptions, to be low.

When all this is added up, the result is that an economy in which a large part of productive activity, especially in the leading or strategic industries, is owned and controlled by TNCs, will be an economy that lacks its own endogenous technological dynamic. It will be an innovation-taker rather than an innovation-maker. There are many examples of this state of affairs in the developing world: in the Caribbean, in many West African and some East African countries, and even in some of the more advanced developing countries such as Brazil and Mexico -- at least in those industries in which there is a large TNC presence.

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[11] Simon Teitel, "Creation of technology within Latin America", The Annals of the American Academy of Political and Social Sciences. Volume 458, November 1981, pp. 136-150.

In such an economy, one can consider what the effect of Government regulation of technology transfer contracts might be. It is likely that royalty rates and other explicit payments for technology can be reduced. It seems less likely that a substantial diversion of demand from foreign to local sources of technology can be achieved in the leading industries, since TNC subsidiaries will be under considerable pressure to continue taking technology from their parents. Other regulations, for example on prohibiting restrictive practices, can be evaded by unwritten understandings between parent firm and subsidiary. Even restrictions on explicit payments can be compensated by raising transfer prices.

Foreign investment policy may therefore be regarded as a vital --if explicit -- component of technology policy. Of course, this does not mean that technology policy should determine foreign investment policy. The point is rather that the two sets of policies should be in tandem. It seems for instance, that in a country that is set on following "open door" foreign investment policies, it would be pointless to restrict technology imports in the industries that are under foreign control, or to invest heavily in R&D institutes for the creation of local technology in those industries. On the other hand if a country following "open door" policies considers national technological development as an important strategic objective, it should be prepared to at least modify its foreign investment policies.

Industrial development strategy and technology policy

The inter-relatedness of technology policy with other policies is shown by the contrasting experience of other developing countries which, unlike the "innovation-takers", have made some strides in the absorption and adaptation of foreign technology and the generation of innovations. Central to this relative degree of success has been a set of policies with at least four crucial components:

1. Restrictions on the entry of foreign direct investment: it is allowed only in some industries or not at all.

2. Strict control over the form of FDI, preference given to 50-50 or minority foreign-owned joint ventures.

3. Strict regulation of technology imports, to reduce the costs, eliminate clauses that inhibit absorption and modification of imported technology, and subcontract portions of investment projects to local engineering firms.

4. Vigorous policies for the promotion of domestic enterprises and the development of their technological capabilities. These policies include subsidies, tax incentives, protection of the local market, and in some instances direct state investment.

It will be seen that these policies are inter-related and support one another. Indeed, when taken together they amount to an overall strategy of economic/industrial development which emphasizes the role of national capital and the necessity to develop an independent technological base. (Incidentally, this also shows the importance of applying "consistency tests" to national technology/policies).

The Japanese model

The model of the strategy above is almost certainly the course adopted by Japan in the postwar period. Reference should be made to the Andean Pact/IDRC publication Technology Policy and Economic Development[12]. The description provided (pages 22-29) of the postwar development of the Japanese petrochemical industry from selective technological importation in the early 1950s to innovation and technological exporting by the end of the 1960s is excellent, and suggests a great deal of lessons on which developing countries could draw.

Reference should also be made to the complementary industrial policy, known as the "staggered-entry formula", followed by Japan's powerful Ministry of Trade and Industry (MITI). Under this formula, MITI controlled the entry of industrial groups into the production of synthetic fibres and petrochemicals such that successive entering firms or groups of firms, had a guaranteed share of the domestic market for an initial "learning" period. The table below gives the sequential entry pattern for nylon production and polyester fibres, and the chief sources of the licensed technology utilized by the Japanese firms.

The Korean experience

The developing country which has probably patterned itself most closely on Japanese policy is the Republic of Korea, which has followed what may be called a "modified Japanese model". Foreign investment has been highly restricted, being allowed only in those sectors where Korean firms do not have access to the technology or to the export market, such as petroleum refining, chemicals, electronics, synthetic textiles, and apparel. The greater part of capital inflows to Korea has been in the form of debt rather than equity. Korean firms have exhibited an impressive degree of development of technological mastery and innovation in industries such as plywood, textiles and apparel, shipbuilding and capital goods such as textile machinery (e.g. semi-automatic weaving looms) and the mechanical engineering industries.

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[12] IDRC-061E, 1976.

Table 1. Entry pattern of Japanese firms in nylon and polyester production, and their technology suppliers

Company	Year of Entry	Technology Supplier
A. NYLON		
Toyo Rayon	1951	Du Pont (USA)
Nippon Rayon	1954	Inventa A.G. (Switzerland)
Kanegafuchi Spinning	1963	Snia Vicosa (Italy)
Teijin	1963	Allied Chemicals (USA)
Kureja Spinning*	1963	Zimmer A.G. (West Germany)
Asahi Chemicals	1963	Firestone (USA)
B. POLYESTER		
Toyo Rayon	1958	I.C.I. (U.K.)
Teijin	1958	I.C.I. (U.K.)
Toyobo	1964	Chemtrex (USA)
Kurashiki Rayon	1964	Chemistrand (USA)
Nippon Rayon	1964	Inventa A.G. (Switzerland)
Kenegafuchi Spinning	1967	Snia Vicosa (Italy)
Asahi Chemical	1969	Rohne-Poulenc S.A. (France)
Mitsubishi Rayon 1969	1969	AKU (Netherlands) and Glanzstoff A.G. (West Germany)

Source: T. Ozaba, "Government Control over Technology Acquisition and Firms' Entry into new Sectors: The Experience of the Japan's Synthetic-Fibre Industry" in Canadian Journal of Economics, 1980, 4, 133-146, Tables 1 and 2.

* Merged into Toyobo, 1966

Korean enterprises have used a variety of channels to secure needed foreign technology. A survey of 112 exporting firms in 1976 found that foreign and domestic sources were just about equal as sources of process technology classified as "important" by these firms. The leading "important foreign" sources were licensing and technical assistance from foreign firms, experience acquired by the firm's personnel through previous overseas employment, and suppliers of imported equipment and materials. In product innovation technology the role of foreign sources was considerably higher, and the leading "important foreign" source was by far overseas customers for the firm's exports, followed by overseas travel by the staff.

It might be interesting here to look at an extract from an overall assessment of the methods used by the Republic of Korea to achieve its growing technological mastering in a wide range of industries, made in an article by Dahlman and Westphal (1980):

> The purchase of technology through licensing agreements has been of modest importance as the initial source of process technology. Machinery imports and turnkey contracts have been of much greater consequences in the transfer of technology, and a tremendous amount of expertise has been obtained as a result of return of Koreans from study or work abroad ......
>
> In industries in which the technology is not product-specific, the initial achievement of mastery has frequently permitted the copying of foreign products as a means of enlarging technological capacity. The mechanical engineering industries, among others, afford many examples; such processes as machining and casting, once learned from producing one item, can readily be applied in the production of others ......
>
> Export activity has proved to be a very important means of acquiring technological mastery. As a result of exporting, Korean firms have enjoyed virtually costless access to a tremendous range of information, diffused to them in various ways by the buyers of their exports. The resulting minor technological changes have significantly increased production efficiently, changed product designs, upgraded quality, and improved management practices[13].

The Indian case

Another developing country that has adopted similar policies is India, although in this case the role of the public sector and state enterprises has been much more pronounced. India has been highly restrictive of foreign direct investment -- probably more so than the Republic of Korea -- and where such investment is permitted a majority foreign shareholding is allowed only in exceptional circumstances (of which Union Carbide of India, owner of the Bhopal plant responsible for disaster in December 1984, happened to be one). Like Korea, Japan, and the socialist countries, India has made substantial use of arm's-length transactions for the acquisition and assimilation of technology by domestic enterprises. Licensing and, more generally, technical collaboration agreements, have been the principal means of importing technology. Government regulations governing these agreements have emphasized limiting the duration and providing the conditions for effective absorption and adaptation of the technology supplied.

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[13] C.J. Dahlman and L. Westpal, "The Meaning of Technological Mastery in Relation to the Transfer of Technology", The Annals of the American Academy of Political and Social Sciences, Vol. 458, November 1981, pp. 22-24.

The impressive development of the Indian capital goods industry has been based on this kind of strategy. In this industry, foreign direct investment has been limited to minority equity participation, and Indian enterprises have secured foreign technology by means of joint venture and technical collaboration agreements (the latter have been made not only with Western TNCs but also with socialist countries' state enterprises). For example between 1970 and 1979 a total of 563 technology agreements were made for the production of electrical machinery, 519 for electrical equipment, 161 for machinery tools, and 136 for metallurgical industries. It may be noted that during the same period the value of India's production of engineering goods grew from $4 billion to $15 billion, accounting for 20 percent of manufacturing output (value added) in the latter year[14].

An example of this process at the level of the individual enterprise is the case of the Hindustan Machine Tools Company (HMT). This successful public enterprise actively utilized technology strategies in its transformation from a machine tools manufacturer in 1953 to a diversified industrial complex by the 1970s. HMT used at least four different methods for the acquisition of foreign technology (i) formation of joint ventures with foreign firms for the initial establishment of an industry (ii) selective purchase through licensing, (iii) bulk purchase of machinery, and (iv) joint development and co-operation with foreign firms of new technologies. To complement this, HMT developed a variety of deliberate activities for the absorption and adaptation of the imported technology, and for the generation of domestic technology within the firm. By the late 1970s HMT was manufacturing thirty-eight types of metal-cutting and metal-forming machines, as well as automatic watches, tractors, lamps, and lamp-making machinery. Reference should be made to the excellent study of HMT by Mascarenhas[15].

The role of consumption policy

Consumption policy refers to measures taken by a Government that influence the level and pattern of personal consumption within the economy. We are especially interested here in those aspects of Government policy that affect -- explicitly or implicitly - the composition of personal consumption as between different groups of commodities (e.g. food, clothing, transportation) and between different types of commodities within the same group (bread vs. root crops, processed food vs. fresh food, motor cars vs. scooters, etc.).

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[14] Information taken from UNCTC, Transnational Corporations in World Development: Third Survey. United Nations, 1983, para. 450.

[15] R.C. Mascarenhas, Technology Transfer and Development: The Case of India's Hindustan Machine Tools Company. Boulder, Colorado, The Westview Press, 1982.

What is the relevance of this? Simply that it is the composition of personal consumption which prescribes, in large measure, the set of "product possibilities" in the economy - i.e. the type of products in demand and the quantity demanded of each. (The other sources of demand are Government spending, investment spending, and exports, but personal consumption is usually the largest single category of demand). And the product possibility set, in turn, prescribes the set of potentially usable techniques. For products that are not consumed at all, or consumed only in small volumes, the techniques used in their production are just not usable from the economic standpoint -- unless, of course, the composition of consumption is changed. In other words the demand for technology (production techniques) is derived directly from the level and structure of productive activity, and indirectly from the level and structure of consumption.

Consider the case of a country in which per capita income is in the middle range for developing countries ($600 - $1,000), urbanization is relatively high (50 percent of the population in towns), and income is fairly unequally distributed (the top 15 percent of households earning 60 percent of total household income). It is likely that consumer demand in this economy will be biased heavily towards durable consumer goods, expensive housing, motor-cars and other products associated with affluent urban life styles copied from the developed countries. Accordingly, the techniques demanded will be those used in the production of developed-country products. Naturally, the TNCs from those countries have a decided advantage over domestic enterprises in the supply of these techniques.

These tendencies will be strengthened by Government policies which allow TNCs relatively free entry into the economy, and by aggressive TNC strategies of advertising and marketing aimed at heightening product differentiation. Simply put, "product differentiation" refers to the efforts of firms in a market in which there are few sellers, to persuade buyers that their product is different from those of their main competitors even if it serves the same basic function: e.g. "Bayer" aspirin, "Colgate" toothpaste, "Tide" detergent, etc.

Breaking up the market for a particular product type into segments attached to specific brand names further limits the usable production techniques to those associated with these brands. Since these are usually covered by industrial property rights (patents, registered trade marks and brand names) the TNCs that control these techniques enjoy a near monopoly position in the supply of production technology. At the same time, there is no incentive to substantially modify imported techniques, support the development of indigenous innovations, or use the services of local R&D institutes.

Stephen Langdon has described, in eloquent terms, the way in which this process worked in a developing African economy. The following is an extract from his Multinational Corporations in the Political Economy of Kenya.

> At a more general level, it would seem that there was a similar and pervasive mnc impact on local firms, across a wide range of consumer goods sectors. Mnc taste transfer was redefining the basic need for drink into demand for Coke or Pepsi; the basic need for food into demand for Lyons Maid ice cream or Cadbury's chocolate bars; the basic need for medical aids into demand for Aspro, Cafenol or Cofta; the basic need for baby nourishment into demand for Lactogen or Glucorin; the basic need for transport into demand for Peugeots and Mercedes, and so on. Not only did these translations, as in the soap case, often leave the consumer worse off, paying higher prices to satisfy redefined basic needs. They also generated industrialization inappropriate to Kenya's resource base and employment needs. And they established patterns of demand that were very hard for small-scale, indigenous Kenyan industrialists to try to meet directly. In that sense, the mnc role in Kenya seemed responsible for blocking in a general way, the development of decentralized local industry in a wide range of sectors.

Hence, the transfer of developed country consumption patterns to developing countries inevitably raises the demand for foreign technology and dampens the demand for local technology which produces functional substitutes (if not exact replicas) of the products in question.

A Government policy that encourages such "taste transfer" (to use Langdon's term) is implicitly discouraging indigenous innovation in consumption goods, whatever may be the declared objectives of its explicit technology policy. By the same token, consumption policy can also be used to broaden the range of production techniques in demand, and to indirectly encourage local innovation.

For example, in a country with the same per capita income as the one above, if government policies favour egalitarianism in income distribution, and rural development as against urbanisation, then the entire pattern of demand can be expected to be quite different. The demand for consumer durables, and differentiated consumer products will almost certainly be lower, while the demand for simple consumer goods serving the basic needs of food, clothing, shelter, medical and educational services will be very strong. Such products require technologies that are more "mature", more widely available from a variety of suppliers, and more susceptible to local adaptive and innovative effort.

It is interesting to consider the fact that China, which concentrated heavily on satisfying basic needs and promoting rural development in the 1950s and 1960s, purchased very little proprietary technology from the West during that period, and elevated the principle of technological self-reliance almost to the level of theology. Even now, its much-publicized imports of Western technology are mainly for its capital goods and basic materials industries, such as oil and fertilizers.

Consumption policy also applies to the choice of product, or product specification, within the product group. Frances Stewart has pointed out that:

> The introduction of product into the question of choice of technique thus appears to limit further the available choice and support the view of the technological determinists — that there is only one "best" method of production and that is the one currently installed in the West. However, the same argument can be used in the opposite way, to show the effective choice of technique is *wider* than is generally supposed. Choice is extended once it is recognized that the choice may extend to product, in both quality and type, as well as method of production to produce the same, homogenous product[16].

One of the main instruments a Government can use in this area is the regulation of licenses for the use of foreign product patents, including the use of trade marks and brand names. Product patents may be disallowed where a satisfactory functional substitute is available locally, or where the intrinsic value of the foreign product is judged to be not worth the social cost. Regulations can also prohibit the payment of royalties for the use of foreign trade marks and brand names on the domestic market, or even ban their use altogether. Government regulation of licensing is further considered in the next presentation.

Apart from this, there is a large number of Government policies that are adopted for other purposes, but which have side effects on the level and pattern of consumption. These include taxation, subsidies, credit, industrial promotion, tariffs, quantitative restrictions, agricultural development programmes, price support schemes and pricing policies, and of course foreign investment policy. In practice, it will be difficult to bring about a situation in which *all* these measures operate in the same, consistent direction as regards their impact on consumption. The important thing is to keep them under observation, to seek to avoid major *inconsistencies*, and to strive for the maximum harmony between technology policies and the policies for industrial development, foreign investment, and consumption.

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[16] Frances Stewart, *Choice of Technique in Developing Countries, Journal of Development Studies*. Vol. 9, No. 1, 1972, pp. 109-110.

NATIONAL TECHNOLOGY POLICIES AND PLANNING

5-THE REGULATION OF TECHNOLOGY IMPORTS

by Maurice A. Odle[17]

Introduction

The remaining presentations on technology policies and planning examine two select policy issues; one related to the demand side and the other to the supply side of technology. This presentation discusses the efforts of many developing countries to control technology imports by means of Government regulation of contractual technology transfer.

Background and objectives to regulations of technology transfer

Government regulation of contracts for technology transfer was hardly evident in developing countries until the beginning of the 1970s. Up until that time, India was probably the only important case of a developing country that required formal Government registration and approval of such agreements. Towards the end of the 1960s there began to emerge a concern among other developing countries, especially the larger and more industrialized ones, about the growing foreign exchange payments associated with these agreements. This was given considerable impetus by a number of pioneering studies conducted by the UNCTAD Secretariat.

During the 1970s a considerable number of these countries joined India in instituting formal regimes for the regulation of contractual technology transfer. These included the most industrialized countries in Latin America (Brazil, Mexico, Argentina, Venezuela, Colombia, and the countries of the Andean Pact), and some in Asia (e.g., the Republic of Korea, the Phillipines, and Malaysia). We can discern four main kinds of objectives in these regulatory regimes:

1. Reducing the foreign exchange costs of technology imports.

2. Limiting or altogether eliminating restrictive clauses in technology contracts.

3. Ensuring effective transfer and absorbtion of imported technology.

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[17] The views expressed herein are those of the author and not necessarily those of the United Nations organization, of which he is a staff member.

4. Limiting technology imports to those which cannot be supplied locally.

The regulatory regimes do not necessarily cover all four objectives in every case. In most cases, the regulations deal at the very least with reducing payments and limiting restrictive clauses. The more sophisticated regimes, in countries such as India and the Republic of Korea, also contain attempts to ensure more effective transfer, and excluding technology imports where local suppliers are available, as a means of affording protection to the latter. In some countries it is possible to discern an evolution of the concern of the authorities from the first and second kind of objectives, to the third and fourth.

We will review some of the features and results of the efforts to reduce costs, limit restrictive clauses, and ensure effective transfer of technology. Some comments will also be made on the efficacy of "unpackaging" strategies by developing countries. Finally, some of the main lessons to be derived from this experience will be outlined.

Measures to reduce the costs of technology imports

Technology suppliers to developing countries frequently -- if not always -- command such superior bargaining power in transactions than the developing country purchases. In the economist's terms, the technology market is an "imperfect" one. This is due, firstly, to the fact that in many industries there is only a small number of suppliers (sometime only one) of the core technologies used, whereas there is a large number of buyers and potential buyers for the technology. Secondly, the suppliers control much of the information that the buyers need in order to bargain effectively. The rationale for Government regulation springs from the need to strengthen the bargaining position of the developing country buyers, and otherwise to remedy some of the imperfections in the technology market.

As regards measures to reduce payment terms and costs in contracts, the following are some of the main principles which have emerged from the regulatory regimes instituted.

1) Running royalties and fees calculated on a value of sales or per unit basis do not take into account the profitability or non-profitability of the enterprise. Hence, steps have to be taken to ensure that the supplier does not charge an arbitrarily high figure. Many Latin American and Asian developing countries have stipulated a maximum figure of 5 per cent of net sales value (gross sales minus imported inputs), save in certain exceptional cases. Similarly, particular scrutiny is made of lump-sum payments since they may not be related to the size of output. In India, there is a tax on royalties and other technical payments based on the difference between the fees and the costs incurred by the enterprise in earning them.

2) Permission should not be given for contracts with "double and triple counting", whereby the supplier not only charges a fee based on sales but also a fee on the value of inputs of materials and equipment supplied. Very often the inputs are tied and the supplier may engage in over invoicing, and then charge fees based on the inflated prices of the inputs. These inflated inputs are then reflected in the value of sales. Many developing countries (e.g., Brazil, Colombia, Philippines, India and Venezuela) therefore insist on a single charge based on the sales value minus the cost of tied inputs.

3) The level of the running royalties can be reduced by regulation where the commodity is becoming increasingly standardized nature, e.g., cars (2%) and hotelry in Brazil and Argentina; or because of the branded nature of the commodity, (e.g. pharmaceuticals in Mexico and India); or because the contract is a renewal of an old one, as in India. On the other hand, the royalty rate may be allowed to be higher than average for export activities, as in Colombia (7%) and in India.

4) If the service that is traded is not intrinsically a technological one but merely one of goodwill, then the fee should be lower. Thus trademarks in Latin America and Asia are usually priced at no higher than one per cent.

5) Intra-firm payments (payments by subsidiaries to parent TNCs) for access to proprietary technology, should hardly be allowed, except for technical services. This is partly because the marginal cost to the TNC of supplying the technology to the subsidiary is usually zero or close to it, and partly because profits by the subsidiary already represent an element of returns to technology. Nor should these payments be considered tax deductible expenses. However, in the cases where the partner is only partly owned (joint venture) pro rata payments are allowed. Many Latin American and Asian countries have so legislated.

It should be noted at the outset that in response to regulatory measures, there is no guarantee that offsetting secret payments may not have been arranged between the technology contracting parties (in the case where the technology recipients are in the private sector) or that the technology supplier may not quote a very high fee at the outset of the bargaining process in the expectation that the regulatory authority would stipulate a lower fee. Also, in the case of parent-subsidiary relationships, when technology fees are restricted there may be a compensating rise in repatriated profits or in the degree of transfer pricing of intermediate inputs supplied.

However, there is evidence that the cost reduction regulatory measures seem to have had the desired impact in Latin America (the region with the strongest legislation). The annual rate of growth of technology payments from this region to the US, for example, fell from 11 per cent in the 1960s to 2 per cent in the 1970s without any appreciable rise in repatriated profits. Information on the incidence of transfer pricing is not available. At the same time, there was no perceptible decline in the rate of growth of US direct foreign investment to Latin America. In contrast to the Latin American experience, US receipts from the rest of the developing world in the 1970s grew not only faster than in the 1960s but also faster than aggregate world receipts, owing to a lower regulatory effort in these countries.

Some individual Latin American countries have achieved considerable cost reductions. For example, in 1977 in Colombia, of 104 agreements, reduction of royalty was requested by the regulatory authority in 34 cases, in addition to 14 cases for differential royalty rates. In Venezuela in 1978, of 245 draft agreements, 46 per cent were reduced on average by 20 per cent. Outside of Latin America, the Philippines has also achieved substantial reductions.

In recent years, with the intensification of the economic recession and the resultant scramble for direct foreign investment, there has been a relaxation of the payment regulations in one or two countries. For example, in Korea from 1978 royalties of less than 10 per cent of net sales or $1 million lump sum received automatic approval and, in Argentina, (starting from 1976) control over intra-firm payments and the size of royalty payments was abolished, and the degree of import restrictions pertaining to intermediate goods was reduced.

Measures to limit restrictive practices

Restrictive practices inserted into contracts by technology suppliers are intended to maximize profits and fees in the short run and, by retaining ownership and control over the technology, to also maximize profits in the long run. The same Latin American and Asian countries that have been in the forefront of trying to reduce the costs of imported technology have either concurrently or subsequently been involved in trying to eliminate the most adverse of the restrictive practices pertaining to such contracts. For example of 4,600 contracts examined by the Mexican Registry of Technology Transfer by the late 1970s, revision had to be made, inter alia in 31.6 per cent of the cases due to excessive duration of agreements, 30.7 per cent due to prohibition on use of non-patented technology after contract expiration, 16.8 per cent owing to a "grant-back" clause and 14.5 per cent due to export restrictions (as well as 68.5 per cent owing to excessive payments). Other major causes for revision included restrictions on volume or price of output and on tied inputs.

In recent years more developing countries (e.g., Peru and Korea in 1981) have become very concerned about restrictions relating to duration of agreement and to post-contractual use of the technology. The maximum duration of an agreement is usually 5 years (e.g., Brazil, Colombia, Malaysia, India and the Philippines) so as to reduce the period of technological dependence. As a result, explicit training programmes had to be included in the contracts to ensure technological absorption within the contract period. Given a shorter duration period and the policy of contract renewal only in exceptional circumstances (e.g., new technology or exporting -- India and Philippines) it became increasingly necessary to ensure that there was no restriction on the use of the technology after the expiration of the contract.

On the other hand, in recent years a few developing countries have relaxed somewhat their prohibitions of certain clauses, partly to allow for more pragmatic and case by case examination of agreements and partly because of the exigencies of the international economic crisis. These countries include Venezuela (1976), Philippines (1978), Nigeria (1979), Peru (1981) and Mexico (1981).

Results

If the non-appearance of restrictive practices in contracts is any guide, then the regulatory policy of Latin American and Asian countries, in particular, can be considered to have been a success. However, it should be noted that parent TNCs do not need to insert such clauses in their contracts with subsidiaries since a tacit arrangement could obtain. Similarly, local private sector recipients could collude with the TNC technology supplier to circumvent various regulations, providing the costs involved are social rather than private. Some local enterprises may simply be interested in maximizing profits via the fabricating of a well tried and tested product (using imported technology) rather than in national technological transformation, per se.

Measures to facilitate effective technology transfer

In addition to trying to remove the negative effects of various restrictive practices, the regulatory authorities have also attempted to introduce a number of positive measures, in furtherance of the goal of developing a genuine indigenous technological capability.

(i) Quantitative Performance Requirements

Exporting obligations are becoming a major performance requirement for manufacturing concerns in some countries owing to serious balance of payments adjustment problems. In 1977, of 7060 US enterprises in developing countries, 4 per cent were required to export a certain minimum amount. Despite debate about how consistent export requirements are with the GATT and Tokyo Round agreements, a strong view is that they are fundamentally different from export subsidies, such as value rebates, low profits tax rates, special credits, and dual exchange rate, in that they are pre-conditions rather than incentives for export-centred production. (Export requirements also complement the sub-contracting activities of the TNCs and the efforts of the local authorities in setting up export processing zones).

Local materials content is a requirement for enterprises either placing ceilings on imported or establishing minimum local content for inputs. Frequently, the import limitation is linked to the export requirement. Companies are required either to balance a certain percentage of their import needs through exports of the finished commodity or to qualify for duty free importation of inputs to the extent that they are used in exports.

Local labour content is a rather prevalent performance requirement. In 1977, of 5,930 US enterprises in developing countries, 1384 or 19 per cent were required to use a minimum amount of local labour or add a minimum amount of labour content.

(ii) Qualitative Performance Requirements

Recent regulations have required, inter alia, (a) the full disclosure of all technical information to be contained in the technology agreement (Brazil and Peru); (b) full access to future improvements in the technology (Philippines and Malaysia); (c) transference of ability to maintain product quality (Malaysia, Colombia, Ecuador and Mexico); and (d) an effective training programme (passim).

Training is now being taken very seriously by the regulatory authorities. Brazil, India and Nigeria have set up training programmes. The Philippines requires TNCs to submit an annual report on their activities relating to the training of local employees and on the progress being made to replace expatriate employees with indigenous personnel. The oil producing countries of Chad, Colombia, Indonesia, Peru and the Gulf States require that training programmes be jointly organised by the State and the TNC and that preference be given to nationals in the company's hiring practice. Ecuador requires 95 per cent of the workforce to be nationals (but only 65 per cent of the technical staff). Malaysia requires a certain percentage of profits to be allocated to research and training, and Guatemala stipulates the amount to be spent on scholarships and schools.

Despite the above, most developing countries still fail to have included in their technology agreement a clear training programme (rather than vague references to training) which spells out the number of persons to be trained and the level and type of skills that are to be attained.

Compulsory licensing (re patents) is being resorted to by an increasing number of developing countries in order to combat the practice of the TNCs of registering most of their inventions without actually working/utilizing them. This effectively keeps out would-be competing foreign and domestic producers and relegates the developing country to the role of importer. Following the Latin American example, several developing countries have given themselves the power of legal intervention. For example, in Nigeria, in the name of public interest; in the Philippines if local demand is not being met; and in India if the patent is not being offered at a reasonable price. Where the TNC is forced to work the patent, the regulatory authorities still need to ensure that the effect is not violated by including in the licensing agreement secrecy provisions or non-disclosure clauses (re the nature of the product or the chemical/engineering processes), and that the legal validity does not extend beyond the stipulated life of the contract. In this regard, some countries have also tried to reduce the period of validity of the patent itself.

Unpackaging

Unpackaging refers to the attempt of the regulatory authorities to disaggregate the technological function into "core technology" - which is intrinsic to the engineering process and can only be acquired from the foreign supplier - and "peripheral technology", which can be supplied locally. Frequently suppliers try to insist on supplying a complete package, not only in order to supply more technology than the developing country actually needs, but also to make it difficult for the recipient to determine how much each item actually costs. Brazil has tried to defeat this practice by obliging the parties to frame transfer of technology agreements under pre-determined contractual categories - license on patents, licence on trademarks, supply of industrial technology, specialized technical services, etc.

Unpackaging the various components of the technology package - civil/mechanical/electrical construction, operations, proprietary and other types of know how, management, purchasing and marketing, etc. - can occur with respect to any sector; but the activity that probably lends itself most for doing so is the turnkey project. In Brazil, India, Mexico and Korea, there is a growing trend to replace turnkey contracts with a basic engineering services contract.

In some cases the turnkey plant has failed to operate at its rated capacity and experienced a considerable amount of post-commissioning problems. In response to this, recipient enterprises have often converted the turnkey contract into an "extended turnkey" or "product-in-hand" contract, in which the contract is extended to include the period of initial operations.

Role of State Enterprises: Capital goods and basic materials like petrochemicals, fertilizers, steel and power industries greatly facilitate the construction and operational stages of turnkey projects. In the semi-industrialized countries of the Third World, the state sector frequently accounts for the bulk of capital goods activity, partly because of the large capital requirements, the high technological risk involved, the long realization period, and the strategic nature of the industries.

For example, the state accounts for 92 per cent of capital goods activity in Algeria and 80 per cent in Egypt. Even in the Philippines, machine tool production has been initiated through a state-owned company. But it is in India that state has the greatest experience, partly because of the size of the market and the considerable industrial base. (In both Brazil and Mexico, the role of the state in capital goods production, though large, is considerably less.). Indian state-owned enterprises account for the production of heavy electrical equipment and heavy-mechanical equipment, including machine tools, heavy-duty pumps and compressors, power boilers, and material handling equipment. In the Indian case, the technology was acquired not only from the traditional Western market economies but also from the USSR and other East European sources. Although sourcing from East European countries allows for maximum unpackaging (in 1977, 8.6 per cent of all Argentine contracts were with Eastern Europe) the problem of inadequate unpackaging frequently lies with the recipient state-owned enterprise, irrespective of the source of the technology or type of sectoral activity, for several reasons:

(a) There is frequently inadequate co-ordination of organizational and administrative skills to bring the work of various more or less autonomous institutions to bear upon the formulation and implementation of specific projects.

(b) Because state-owned enterprises do not attempt to pool their technical knowledge, the critical mass of knowledge each has acquired is under-utilized.

(c) Public enterprises operate like "states within a state" and frequently fail to take cognizance of the government's own technology policy and contractual guidelines. One reflection of this is the eagerness to seek foreign sources of technology without exhausting the local sources, e.g. one study of the Andean Pact countries found that 87 per cent of the state-owned enterprise did license their technology. In addition, some public enterprises in developing countries did not register their technology agreements, let alone seek the approval of the regulatory authorities set up to scruti-nize the inflow of technology. Moreover, the contracts contained the full range of restrictive business practices and there were few guarantees concerning adequate training.

(d) Certain developing countries, because of their newly won large petroleum revenues, became less enthusiastic about hard bargaining with foreign suppliers.

(e) Some developing countries (mainly the oil importers) did not try sufficiently hard to withstand the tied nature of World Bank financing. For example, for power projects the World Bank would accept a bid by a domestic supplier which falls within a 15 per cent price differential limit (i.e. above developed countries' prices); however, the cost differential for most power equipment manufactured in the developing countries tends to be 20-50 per cent. According to UNIDO, a 25-30 per cent price differential on most capital goods should obtain for the first five years, 20 per cent after ten years, and appropriate reviews afterwards. UNIDO also recommended a 25-30 per cent import protection.

Monitoring and evaluation of technology import regulations

In India, the Philippines, and Latin America (Argentina, Colombia, Mexico and Venezuela) attempts have been made to introduce a system of monitoring and evaluation of the technology importation process so as to assess the absorption, adaptation, and improvements made by the recipient enterprise. In India, where this regulatory machinery is the strongest, no contract is renewed without an evaluative exercise; between 1974 and 1980 there have been at least 300 evaluative exercises. In the other countries the monitoring cum evaluation system is only in its infant stage, although in the Philippines enterprises are required to submit annual reports containing information on (a) benefits being derived from the technology agreement; (b) the rate of implementation of the training programme, especially to replace foreign personnel; (c) R and D activities and (d) progress in adaptation of the technology to suit local materials and environmental conditions.

Remaining weaknesses in the regulatory system

As a result of over ten years' experience in many developing countries, the following weaknesses which have become evident, can be highlighted.

1. In addition to the problem of monitoring and evaluating, very little control has been exercised over the selection and sourcing of technology at the enterprise level.

2. Insufficient concern has been shown over how far the removal of restrictive practices has brought about the desired results, particularly with respect to foreign subsidiaries.

3. Little control has been exercised over the pricing of inputs supplied, particularly with respect to foreign subsidiaries.

4. Public enterprises are failing to maximize their vast bargaining potential.

5. National institutions concerned with regulating technology imports and those expressly concerned with developing a local design and engineering capability do not co-ordinate their activities sufficiently; in fact, some parts of the institutional infrastructure are irrelevant.

6. Limitations on technology control present in joint venture arrangements (a supposed substitute for majority foreign ownership) are not sufficiently appreciated. Joint ventures are no panacea; they do not necessarily bring about effective participation in technological decision-making and technology transfer.

7. Small countries have too frequently assumed that they lack bargaining power, and, therefore, have not attempted to benefit from the experience of the larger and more industrialized developing countries.

8. Regional Integration Movements, by not pooling their technological resources, have failed to maximize their technological strengths and minimize their technological weaknesses.

9. There is little or no technological exchange (concerning the contents of technological agreements, inter alia) between Third World countries.

10. A legally binding (rather than voluntary) International Code concerning the transfer of technology is yet to emerge.

Conclusion

In those countries with the strongest regulatory regimes, there has been no reduction in inflows of direct foreign investment or in non-equity licensed technology. In fact, the reverse has happened. This suggests that developing countries can exercise some bargaining power and do have some room for manoeuvre. However, the semi-industrialized countries tend to have more leverage (vis-a-vis the TNCs) than the other developing countries, ceteris paribus.

NATIONAL TECHNOLOGY POLICIES AND PLANNING

6-THE ROLE OF ENGINEERING AND CAPITAL GOODS INDUSTRY

Introduction

In this presentation we will be looking at one particular aspect of supply side policies: the strategic role which may be played by engineering services, and the capital goods industries, in the building of indigenous technological capabilities.

The role of engineering services

What exactly do we mean by engineering services? It may be useful to start with the following definition by Kamenetzky[18]:

> Engineering services use scientific and technological knowledge to:
>
> - design and build new production units; and
> - optimize existing units and keep them in operation
>
> The fundamental economic activity of engineering is, therefore, the provision of services for production. It involves the transformation of usable knowledge into used knowledge. In addition, engineers may also provide services for the creation of knowledge by taking part in scientific and technological research (p. 44).

Pre-investment, investment, and post-investment activities all require the performance of various types of engineering services. A schematic view of the relationship of engineering services to these activities is set out in Table 1 below.

Consulting engineering and the preinvestment stage

Kamenetzky argues strongly in favour of the involvement of local engineers in preinvestment work, and the building up of local teams of consulting engineers for the provision of such services. He advances

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[18] Mario Kamenetzky, "Preinvestment Work and Engineering as Links Between the Supply and Demand for Knowledge" in D.B. Thomas and M. Wionczec, (eds.) Integration of Science and Technology.

Table 1. **Relationship of engineering services to investment and production activities**

ACTIVITY	SERVICE
Pre-investment stage	
Prefeasibility studies Feasibility reports w/ preliminary engineering	Consulting engineering*
Investment stage	
Design	Design engineering
Construction	Civil and construction engineering
Commissioning and start-up	Production engineering
Post-investment stage	
Production and maintenance	Production engineering

* The term "Consulting engineering" can also be used to refer to any type of engineering service (design, civil, production, etc.) that is provided by an independent organization in the form of consultancy.

several convincing reasons for such a policy, viz:

- proper preinvestment work requires a thorough knowledge of the peculiarities of the local economic, physical, social and cultural environment. Failure to take these adequately into account may result in fundamental design faults that are extremely costly in the investment stage and in subsequent production (see example below).

- preinvestment work requires general rather than highly specialized knowledge and skills. Hence it is more easily within the reach of local professionals and technicians in the early stages of the development of the engineering services industry, and lends itself to collaboration between foreign and local engineering teams.

- it allows the unpackaging of imported technology, facilitating not only adaptation to local conditions, but also subcontracting of some components of the investment project to local suppliers. In addition, as the skills and experience of the local engineering profession grows, investors can move from the "turnkey" mode of carrying out investment projects to the local management of such projects

> which have been broken up into several discrete parts. (pp. 47-49).

Consulting engineering for preinvestment work may thus be a strategic building block in the process of developing indigenous technological capabilities. It provides a point of departure for the cumulative development of skills through "learning" by the involvement in preinvestment activities, leading to the eventual undertaking of more complex tasks in the adaptation and modification of imported technology.

Consequences of inadequate preinvestment work: an example from West Africa

The West African Technology Policy Workshop held in Liberia heard - from one of its participants - of a very instructive example of the disastrous consequences of neglecting preinvestment engineering work[19]. This was the case of the Onigbolo Cement project, a joint venture (1974) between Benin and Nigeria to construct in Benin a plant for the manufacture of 500,000 tons per year of Portland Cement. The main contract for the supply, erection and management of the works was awarded to a Danish firm regarded as a "world-renowned leader in the cement industry." But the main contract also included the work of undertaking a feasibility confirmatory study which, would, inter alia, "confirm the existence of suitable limestone deposits in commercially-mineable quantities, and with appropriate characteristics for the proposed dry-process technology." The author comments that "In retrospect this was a major blunder since this aspect of the contract could not be meaningfully enforced or even monitored."
Hasty or downright inadequate preinvestment work resulted in a number of major delays and problems in the implementation of the project. Thus,

> The scope of the "necessary infrastructure" kept increasing with time. First the Pobe-Onigbolo road (about 30 km) needed to be widened and resurfaced to accommodate the large tonnage of equipment and machinery. The original works site had to be moved in order to facilitate better plant drainage and quarry openings. These gave rise to cost increases Type 1.
>
> Awarding of contract for new infrastructure then caused delays in implementation of some sections of the main contract, especially in the camp erection provisions. This gave rise to cost increases Type 2.

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[19] O. Akin Adubifa, "The Onigbolo Cement Story, or How to Snatch Defeat from the Jaws of Victory." Paper prepared for the IDRC/ARCT/CODESRIA/University of Liberia West African Technology Policy Workshop, Monrovia, October 1982.

> Then it became necessary to re-evaluate the evacuation routes for the product ..... Now that the plant is in full production, the economic route for evacuating 300,000 tons of cement annually has not been completed ...
>
> FLS underplayed ...... technical problems like the explosion of one of the large motors for the cement grinding mill, and the raw material characteristics which now threaten the total commercial existence of the plant. The limestone contains more water than the raw meal is designed for, and the cost of grinding the wet stones and drying the raw meal to specification will seriously affect the production cost, and may make the final product pricing uncompetitive in any market. One must add that this raw material problem is a direct result of the strategy failure by which feasibility confirmatory study was to be undertaken after contract commitments. (paras. 8, 24-26, 33).

Hence, both capital costs and subsequent production costs were increased as a result of inadequate preinvestment work. Incidentally, the author of this study also suggested in discussion that the reason why the limestone contained more water than expected was that the raw material survey was carried out in the dry season in Benin, and did not consider the fact that there is also a season of heavy rainfall!

The study also suggested that appointing a foreign consulting firm to monitor the implementation of the project is no guarantee against bad performance.

> Almost as an afterthought, a monitoring consultant was employed. The Henry Pooley Atkins Co. of the U.K. was selected from amongst five bidders. But there were to be unfortunate conflicts since certain negotiations had been agreed to with the main contractors before negotiating with the consultants. There was also to be corporate personality clashes (at the client's expense) between a world renowned manufacturer, and a small consultant with powers to monitor and control the manufacturer.
>
> It is ..... dubious that there is much value in Nigeria's requirement that such projects must have a monitoring consultant (foreign of course) to ensure that the contractors fulfil their obligations totally. The most painful part of it is that there is usually no requirement to attach local staff as counterpart to the foreign consultants because this will almost double the consultancy costs. It is not only a matter of wrong premise, but also of wasted investment since local staff never learn to carry out these vital functions. (paras. 9, 14).

Design engineering

Design engineering comprises a complex and highly specialized set of activities. An excellent summary of the kind of tasks which can be involved is provided in the following passage by Roberts and Perrin[20]:

> The act of investment requires the solution of multiple problems of adjustment and adaptation between men and machines incorporating past experiences. For example:
>
> - a product must be adapted to market or other specific requirements
>
> - processes need adapting to product needs, plant size and raw material constraints
>
> - machines need adapting to processes
>
> - machine specifications must be made mutually consistent so as to produce a "jointly optimised" whole
>
> - utility circuits and handling equipment must be adapted to the needs of the central process equipment
>
> - buildings have to be designed round all the foregoing
>
> - the whole plant must be adapted to its wider environment consisting of climatic conditions, soil structure, transport facilities, limitations on pollution, etc.
>
> - manpower has to be adapted through training to the operation of the plant
>
> ..... with the growing complexity of technologies and size of plant, achieving all the necessary adaptations requires increasing specialization in knowledge and skill and even more perfected methods of work and internal organization ..... (therefore) design engineering requires highly qualified staff with a long experience and detailed knowledge gained through the performance of relevant work. (pp. 9-10, 1, emphasis added).

In the economist's terms, design engineering is a crucial activity in the process by which production techniques, including new techniques (technical change) are incorporated into machinery, equipment, and plant through the generation of specific designs and specifications. The other crucial activities are the actual manufacture of the machinery and equipment and its installation as complete plant. Hence design engineering organizations of necessity work closely with

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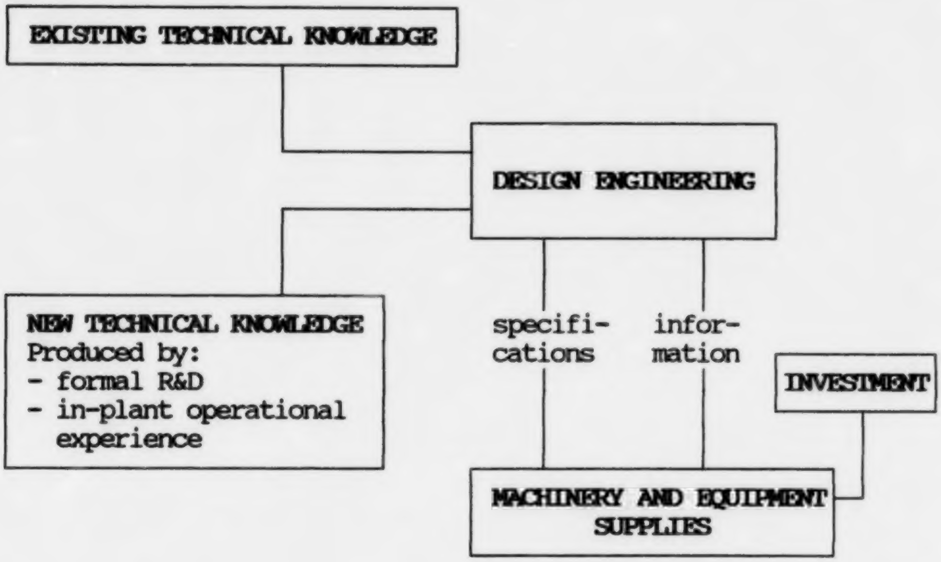
[20] J. Roberts and J. Perrin, "Design Engineering and the Mastery of Knowledge for the Accumulation of Capital in Developing Countries" IREP, University of Grenoble, Sept. 1971, pp. 9-10, 1.

Figure 1. Relationship of design engineering to technology, capital goods production, and investment


EXISTING TECHNICAL KNOWLEDGE
DESIGN ENGINEERING
NEW TECHNICAL KNOWLEDGE
Produced by:
- formal R&D
- in-plant operational experience
specifi-cations
infor-mation
INVESTMENT
MACHINERY AND EQUIPMENT SUPPLIES

machinery and equipment suppliers, providing them with specifications and inter-acting constantly with them on the properties of materials, machinery performance parameters, etc. A schematic view of the relationship is set out in Figure 1.

Assessment of engineering capabilities: an example from the Caribbean

At this point it may be useful to refer to the actual results of empirical research aimed at assessing the level of development of engineering capabilities in a particular developing region -- the Caribbean. The research in question was conducted by C. Solomon, as part of the Caribbean Technology Policy Studies (CTPS-II) project[21].

Solomon surveyed a total of twenty-four (24) of the largest engineering consultancy firms (i.e. firms providing engineering services of whatever type through consultancy) in Jamaica (11 firms), Guyana (7), and Trinidad-Tobago (6). The firms were first classified according to the industrial bias of the engineering services offered (see Table 2).

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[21] Cyril Solomon, "Analyzing Regional Engineering Consulting Firms", Paper prepared for CTPS-II, December 1982.

Table 2. **Industrial classification of main services offered by 24 engineering consultancy firms in Jamaica, Guyana, and Trinidad, 1981-82**

Classification	No.	Percent	Total
Purely civil/structural	15	62.5	
Civil/structural w. mechanical/ electrical capability	4	16.7	
Purely mechanical/electrical	3	12.5	
Purely architectural	1	4.2	
Integrated: civil/structural, mechanical/electrical, and chemical	1	4.1	
Total	**24**	**100.0**	

Source: Cyril Solomon, "Analyzing Engineering Consultancy Firms" Report prepared for CTPS-II, December 1982, pp. 17-18.
As the author comments "Outstanding in their paucity or absence are capabilities in the fields of metallurgy, mechanical, electrical, chemical and mining engineering. These are crucial areas if engineers are to make a serious contribution to the structural transformation of the regional economies."

Solomon also assessed the capabilities of the firms according to the stage in the preparation and execution of projects. His conclusions on the main areas of strength and weakness are set out in Table 3.

Here the author comments that:

> Most local engineering consultancy firms may be performing routine, peripheral activities surrounding most projects. They may be doing routine designing, procurement of the relatively small proportion of indigenous resources, and assisting with supervision, acting as buffers between the expatriate managers and the large labour force of mainly low-skilled local workers.
>
> But when it comes to the more demanding areas of project management, training of personnel to man the new facilities and activating those facilities to achieve set production standards, the expertise of local personnel is inadequate and it is the foreign consultants in the main who have to act out these roles. (pp. 56-57)

Policies for the promotion of design engineering activities

Can developing countries with meagre resources afford the substantial

Table 3. Ranking of areas of capability of 24 engineering consultancy firms in Jamaica, Guyana and Trinidad-Tobago, 1981-82.

Rank	Area of capability
1	Studies, surveys and reports
2	Supervision of construction, Installation, Connection and Erection
3	Engineering design
4	Procurement
5	Project management
6	Start-up and commission
7	Hiring and training and personal
8	Trouble-shooting, maintenance and repair
9	Further development of products and processes

Source: Solomon, op. cit. p. 60

investment, and the long gestation period, involved in setting up design engineering organizations? The costs of such policies are not only the direct expenses of human and material resources, but also the costs of "learning": the delays, uncertainties and higher material costs of the projects assigned to local firms compared with experienced foreign design engineering firms.

Roberts and Perrin argue that the justification lies in the contribution of a design engineering capability to the capacity for indigenous capital accumulation in the economy.

> Design engineering, therefore, may be seen as a vital link in a two phase process conducive to the development of an indigenous capacity to accumulate capital -- at least in those industries where the enterprises' own services are unable to perform those functions without the outside help of a specialist, full-time organization. If the requisite dialogue can develop between design engineers and project planners on the one hand and machine builders and R&D workers on the other -- which of course supposes the prior existence of the latter and therefore a certain scale of operation -- the industrial economy as a whole can acquire after a time the mastery of technique and knowledge which enables it to

> pass from mere "on the spot modifications" to its capital structure to the remodelling and readaptation of productive investment thanks to the "wider range and greater power of assimilation" of which Solow speaks.[22]

They show how design engineering organizations can begin with the establishment of engineering departments in major enterprises in developing countries, especially those engaged in heavy industry. Examples are provided of the Planning and Development Division of the Fertiliser Corporation of India, the Central Engineering and Design Bureau of Hindustan Steel Ltd., also in India, and the engineering department of the Societé Nationale de Sidérugie of Algeria. All three organizations evolved out of in-house engineering departments set up to correct problems in plant operation resulting from the original (foreign) designs, and to engage in preventative maintenance. Eventually, and as a result of experience gained in problem-solving, these departments progressed to the engineering of improvements in design and processes to increase plant production ("capacity-stretching"), and to undertake engineering studies, alone or in collaboration with foreign firms, for the expansion of the plant or the construction of entirely new plants.

What about the smaller developing countries in Africa and the Caribbean? Can we expect engineering departments with this kind of potential to exist? There is some evidence that the answer could be "yes", although with qualifications. Mitschke-Collande and Wangwe have written a thought-provoking article on the capabilities and potential of the central engineering workshops attached to major enterprises in Tanzania[23]. They refer to a particularly interesting case:

> The CWS of AMBONI is an example of a 100% foreign privately owned enterprise which has an exceptional innovation policy. AMBONI being inhibited from exporting all of their profits are prepared to reinvest systematically in various engineering manpower in a way which enabled them to install a complete sisal spinning mill and to manufacture some of the equipment locally in the CWS.
>
> AMBONI CWS must be considered as an extremely advanced institution of production innovation. This can only be explained by a very favourable combination of factors:

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[22] Roberts and Perrin, op. cit. p. 11. The reference at the end of the extract is to R.M. Solow, "The capacity to assimilate advanced technology", in American Economic Review, May, 1966.

[23]. P.V. Mitschke-Collande and S.M. Wangwe, "Structure and Development of the Engineering Sector in Tanzania". ERB Paper 77.11, University of Dar Es Salaam, 1977.

- There is a systematic policy of preventive maintenance and planned replacement of all capital equipment;

- There is an extended off and the on-the-job training scheme in collaboration with the National Vocational Training Programme (NVTP);

- There are several experienced expatriate engineers;

- There is a design and drawing office with a skilled draughtsman; and,

- Last but not least, there is a policy of import substitution of producer goods and the necessary funds allocated for technical innovation. (pp. 29-30)

Similarly, in the Caribbean, there is some evidence of development of engineering departments with some capabilities in the major industries such as petroleum, bauxite, and sugar. In the case of the bauxite industry in Guyana, for example, Bardouille has observed that the local workers in the main producing enterprise (Demba, now Guybau) were known for their "ingenuity ... in the areas of maintenance and general engineering services, constructional and operational crafts (such as welding, fabricating) activities[24] (p. 99).

Roberts and Perrin suggest four kinds of policies for the promotion of the design engineering industry:

i) encourage the development of planning departments in major enterprises. Such departments enable control to be exercised over feasibility studies which define the parameters of the future involvement of local engineering;

ii) encourage the growth of engineering and works departments in enterprises;

iii) encourage collaboration between local engineers and overseas firms of consultant engineers, to facilitate learning; and,

iv) promote the development of the indigenous machine building sector.

The last suggestion takes us into the discussion of the role of the capital goods industry.

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[24] R.K. Bardouille, Technological Capability in the Caribbean Bauxite Industry. Report prepared for CTPS-I, I.S.E.R., 1977.

The role of the capital goods industry

By the "capital goods industry" we mean the manufacture, fabrication, etc. of machinery, equipment and tools and the parts thereof that are used in conjunction with human labour in production. These are several reasons why the promotion of these activities can be a vital part in the building of indigenous technological capabilities. The most important probably are:

1) These activities, and the associated skills, are necessary if imported tools, equipment and machinery are to be adapted to local circumstances, e.g.:

   - the local endowments of labour and capital;
   - the characteristics of locally available raw materials;
   - the size of the local market; and,
   - the nature of the product desired.

In that sense they are an essential complement to design engineering in the adaptation and modification of imported technology.

2) The industry is necessary for the diffusion of innovations (including adaptation and modification of imported technology) throughout the economic system. In other words for technical change to be incorporated into production in producing enterprises generally, it needs to be embodied in a stream of new/improved capital goods that are generally available.

There are also several broader, macroeconomic reasons why the presence of a capital goods industry can be a decided advantage in the overall development process. Among the most important is the mitigation of the "foreign exchange constraint" in the

process of economic growth. This arises out of what economists call the "Two-Gap" model of growth in a developing country; i.e.:

$$S_a < I_r \quad (1)$$
$$K_m < K_{mr} \quad (2)$$

where S = national savings
I = domestic investment
K = capital goods
a = actual
r = required
m = imported

For a healthy rate of growth to be sustained, a developing country must (a) raise the level of available savings, by foreign borrowing if necessary, to the required level of investment, _and_ (b) raise the level of imports of capital goods to that needed to support the required level of investment. The second Gap arises because of the typically high import-content of investment in most developing countries, which is a corollary of the absence of capital-goods industries.

One of the consequences of the second Gap is that a developing country may be forced to engage in foreign borrowing not merely to augment its national savings as such, but also — and additionally — in order to get the foreign exchange to import the needed capital goods. The less-developed, low-income countries in particular have been relying mostly on "tied aid" — multilateral and bilateral loans, and supplier's credits. This usually involves severe restrictions on the choice of technology, and on local involvement in preinvestment and investment activities, with all the adverse effects that we have seen on the development of local skills.

The general point is that the existence of local capital goods industries _expands the scope for transforming savings into investment independently of the foreign exchange constraint_. A number of other factors from the economic standpoint arguing in
favour of the establishment of these industries are given in the World Bank report prepared by J. Datta Mitra.[25]

The feasibility of establishing capital goods industries

The main arguments usually advanced against the investment of resources in these industries are:

- (a) the supposed complexity of the technology and skills required, the difficulty of access to the technology, the difficulty of acquiring mastery over the technology locally, and the associated long gestation period of such investments; and,
- (b) the high costs of production locally as compared to imports, as a consequence of (a), and also the low scale of production due to limited market size.

These may not be arguments against capital goods production _per se_. Rather they point to the need to devise strategies to develop production in activities where (a) the technology can be most easily acquired and mastered locally, and (b) production can be developed at competitive cost in a reasonable period of time.
In this regard we should take note of a number of very interesting

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[25] _The Capital Goods Sector in LDCs: A Case for State Intervention?_ World Bank Staff Working Paper No. 343, July, 1979.

arguments advanced by Cooper[26]. According to this view, the history of industrial technology has been a development through more or less well-defined stages; i.e.:

- i) mechanical,
- ii) electrical,
- iii) chemical, and
- iv) electronic.

Accompanying these stages, there has also been a parallel and related evolution in the *division of labour in innovation*. To paraphrase Cooper, a rough generalization is that formal R&D as a differentiated part of the innovation process is of much greater importance in the industries based on electrical, chemical and especially the electronic, technologies, than in the mechanical-engineering industries. Moreover, "many mechanical innovations are the outcome of interaction between machine users and machine makers and mainly involve engineering designers". These characteristics are also present in some older parts of the electrical-machinery industry, such as the production of pumps and electric motors.

Following from this, Cooper argues that industries where innovation is heavily dependent on formal R&D, especially basic research, are the ones in which developing countries are at the greatest comparative disadvantage. This is both because of the substantial costs of financing such R&D, and the difficulty of access to the technology because it is concentrated in a small number of large enterprises. On the other hand,

> It is expected that comparative costs of building up local innovative capability will be more favourable in such industries as *textiles, clothing, leather processing, food processing, small-scale mechanical and electrical engineering, and agricultural equipment* -- and in such other sectors as *construction, building materials, and water engineering*. The acquisition of innovative skills in these sectors is comparatively easy -- and local metal and machine-making craftsmen may already posses a good deal of relevant capabilities. Consequently, the risks in using local (and less-experienced) engineers, machine designers, and fabricators are less than those in more modern sectors. (p. 28, my emphasis)

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[26] *Policy Intervention for Technological Innovation in Developing Countries*, World Bank Staff Working Paper No. 441, December, 1980.

A study published by the UNCTAD Secretariat[27] reached very similar conclusions to Cooper; i.e.:

> The available evidence suggests that non-electrical machinery, particularly some textile machinery, simple agricultural machinery, standard machine tools and a number of electrical machinery items offer great scope for local manufacture in developing countries. (para. 117)

The line of reasoning is essentially the same as that of Cooper. The UNCTAD report was prepared using contributions from consultants and experts from the Philippines, Argentina, Sweden, Egypt, Brazil, and the Republic of Korea.

The need for research

It would be interesting to test the above conclusions for the smaller, less industrialized developing countries such as those in Africa and the Caribbean. We have already cited some fragmentary evidence of engineering capabilities in workshops attached to major enterprises in countries like Tanzania and Guyana. What would be necessary is a survey, or series of surveys, to determine the characteristics and assess the potential of the engineering and metal-working enterprises -- and *departments* of enterprises -- in the countries concerned. It is also important for such surveys not to overlook the informal sector -- such as small-scale auto-repair shops, sheet-metal craftsmen, blacksmiths, and the like. We would expect these surveys to cover such aspects as the following:

(i) the main products;

(ii) the skills developed and deployed, the sources of skills and of technical information;

(iii) infrastructure, fixed and working capital;

(iv) production costs, and comparison with import prices;

(v) constraints on production level and on reductions in production costs; and,

(vi) impact and role of Government policies.

So far it appears that surveys of this kind have been carried out mainly on the larger and more industrialized developing countries.

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[27] *The capital goods sector in developing countries: technology issues for further research*. UNCTAD, TD/B.6/60, 7 October, 1980.

However the results of these could serve as a useful point of departure for surveys of other countries. For example, an article by Pack[28] reported on the results of recent investigation of the mechanical-engineering sector in Argentina, Brazil, India, Korea, Mexico, Pakistan and Taiwan. Among some of the interesting findings were:

- lower plant-wide labour efficiency relative to developed countries was associated partly with deficiencies in plant layout and production scheduling;
- low capacity utilization in the plants surveyed was associated with production of a wide variety of products, each using a different process;
- there was considerable mismanagement of materials;
- in castings and forging, relatively uncompetitive production costs were due to the high prices and erratic supply of raw materials, internal plant inefficiencies, and small production runs; and
- Government policies often contributed to the maintenance of inefficiencies through indiscriminate and excessive protectionism. Instead, Government support should be (a) selective, i.e. aimed at products where long production lines are feasible and the skills required can be relatively easily developed and (b) complemented by management policies to improve internal efficiency within the plants.

It may be noted that surveys of the small scale metal-working industry -- one for Kenya and one for Ethiopia -- are in fact being attempted within the IDRC-supported East African Technology Policy Studies (EATPS) project.

Conclusion

This presentation has considered the strategic role which may be played by certain kinds of engineering services and capital goods industries, in the building of indigenous technological capabilities. The general considerations are those guiding the strategy for selective development of local capabilities, i.e. the prior existence of some local resources on which new capabilities can be built, requirements for investment that are not unreasonably high, and the possibility of high pay-offs both directly and indirectly.

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[28] Howard Pack, "Fostering the Capital-Good Sector in LDCs", World Development, Vol. 9, No. 3, pp. 227-250, 1981.

It has been suggested that the very least a developing country could aim at initially is the development of consulting engineering capabilities in preinvestment work. Secondly, the capabilities of the metal-working and mechanical-engineering sector, both formal and informal, should be assessed with a view to determining what Government policies can do to encourage its development. In the longer term, the aim should be to develop a full-fledged capability in design engineering and machine-building.

This concludes the series of six presentations on national technology policies and planning. The objective has been to outline some principles, and steps, which may be followed in the formulation of such plans; and then to illustrate these by a discussion of some specific issues: foreign investment and industrial development policy, the regulation of technology imports, and engineering and capital goods.

Throughout the discussion, a number of core themes were constantly emphasized. One was the need for strategy: a long-term view of where we want to go and what steps to take to move us closer to the goal. A second was the relevance of selectivity: broad, across-the-board policies may not be as effective as policies aimed at specific target industries, activities, and enterprises. Following from this was a third theme: the need for continuous research. Indeed the importance of research has been a recurring theme of the presentations in the entire course.

"Technology policy" as a subject area is still very much in its infancy. Moreover, most of what we know or think we know, is drawn from the experience of the larger, more industrialized, developing countries. You will have noticed that the same countries are mentioned over and over again in discussing policies: India, Brazil, Argentina, the Republic of Korea, the countries of the Andean Pact, etc. There is no guarantee that the policy experiences of these countries will prove to be relevant, or effective, in the smaller and less industrialized African and Caribbean countries. Hence, the field is wide open. The need for research, and the testing of new policies, is great. Accordingly, there are great opportunities to make original contributions — to blaze new trails, as it were. Good luck!

SECTION THREE

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